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Teeth and their Substitutes.

By W. P. PYCRAFT.

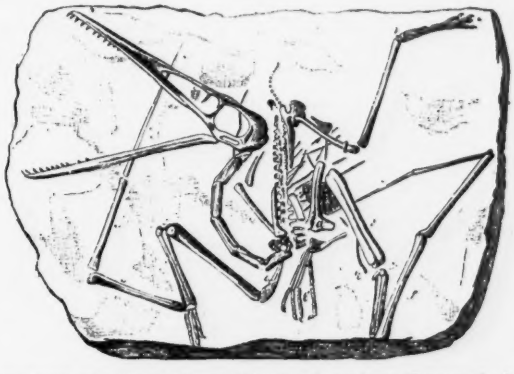
THOUGH Nature evidently meant the vertebrates to be a tooth-bearing race, this design has been by no means rigidly adhered to, as many creatures of very different Orders have been permitted, so to speak, to adopt various substitutes therefor.

The earliest tooth bearers among the limb-bearing vertebrates are to be found among the Shark tribe—using this term in a wide sense—and it is here that we must look for the origin of teeth, searching, if not "with forks and hope," after the fashion prescribed for Snark hunting, at any rate with scalpel and microscope. Properly conducted such a search reveals the truly astonishing fact that the earliest, most primitive forms of teeth are really nothing more than modified scales. In the Sharks, it may be remembered, as in the common Dog-fish for example, the surface of the skin is encased in a mosaic of tiny, closely fitting ossicles, bearing each an enamel-covered spine, and skin so covered was at one time in great request for commercial purposes, being known as Shagreen. In the embryo Dog-fish it will be found that the skin covering the jaws is perfectly continuous with that of the body, and is similarly encased. Later, however, the scales in this region become enlarged and assume the characteristic form of teeth. Among the Sharks this dentition has become modified in many ways, the most striking of all being the evolution of "pavement teeth"—broad flat plates, symmetrically disposed, and used for crushing purposes.

But we are not concerned here with the various forms of teeth, so much as the substitutes therefor, which, for one cause or another, have been adopted by different groups of vertebrates. Suffice it to say, then, that the primitive teeth, embedded as it were in the skin and stretched over the rod-like cartilaginous jaws, gradually assumed a more intimate relation therewith, and sending down "fangs" became rooted in the jaw; while, at the same time, the covering of the body has gradually assumed other forms, so that, among the higher fishes and the rest of the vertebrates, all evidence of this peculiar origin has become obliterated. Furthermore, among each of the great groups of vertebrates more or fewer members have discarded teeth altogether, so far as the armature of the jaws is concerned, replacing these either with tooth-like bodies in some other part of the mouth, or with horny sheaths encasing the jaws.

Among the fishes, such substitutes are to be found in ossified, enamel-coated bodies, of varying shape, situated in the throat and known as pharyngeal teeth, as, for example, in the Carps. On the other hand, it may be mentioned, some fishes have gone to the other extreme, and have, as if to secure themselves against all danger of toothlessness, devised the plan of welding all the teeth in the jaws into a solid mass, and fusing this inseparably with the jaws! And this perhaps to avoid the degradation of false teeth in the shape of the horny sheaths about which we are presently to speak, for in function these dental masses are the equivalents. No fish seems to have descended to such subterfuge.

Among the Amphibia horny bosses simulating and performing the work of teeth are commonly developed during larval life, and are either replaced by minute teeth by the adult, or for the rest of life's journey they remain toothless as in the common toad.



The almost complete skeleton of *Pterodactylus antiquus* (Sommerring), from the Lithographic Stone, Eichstadt, Bavaria (⅛ nat. size), showing the reduction of the teeth.

Left lateral view of skull of *Pteranodon longiceps* (Marsh), from the Cretaceous of North America (⅛ nat. size), to show the horny beak.

Right lateral view of the skull of *Rhamphorynchus*, from the Lithographic Stone of Eichstadt, Bavaria, to show the armature of teeth.

But the Amphibia, as befits their mode of life, seem to wobble a good deal in this matter of teeth; they halt, as it were, between two opinions. For, while some are toothless, others carry a few fine denticles on both upper and lower jaws, or they may be borne only on the upper or lower jaws respectively. They may in addition to these teeth on the jaws have teeth studding the roof of the mouth, or these last may be the only teeth in the head.

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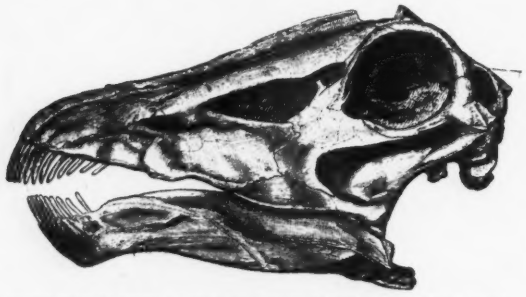
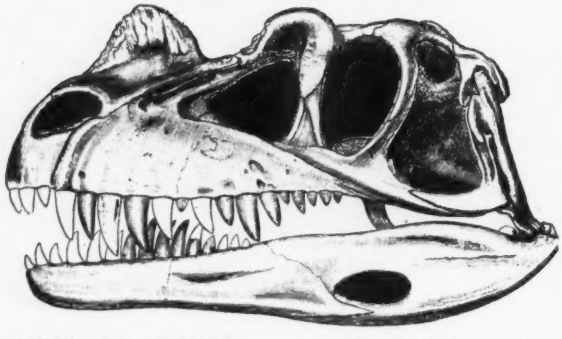
Finally, there are some which seem to have contemplated the introduction of horny teeth during adult life, since the skin covering the roof of the mouth is therein thrown into ridges of hardened skin which may be "denticulated."

The reptiles, as befits their higher grade, are less uncertain in this matter. Among existing species the tortoises and turtles alone have discarded teeth, the jaws being encased, as in birds, in horny sheaths. That their ancestors were tooth-bearing creatures there can be little doubt; but to-day not even embryonic traces remain. We can reckon the more certainly on the truth of this conjecture since among extinct reptiles some very remarkable evolutionary phases in the substitution of teeth by horny casements for the jaws are to be met with. And nowhere is this more beautifully illustrated than in those old Flying Dragons—the Pterodactyls. As may be seen in our text-figures the armature of teeth, in some species at any rate, was tolerably formidable, as for example in *Rhamphorynchus* and *Dimorphodon*. But, in course of time, these teeth gradually dwindled both in size and number, and were as gradually replaced by horn, till finally a horny beak as in birds had come into being. A glance at the illustrations given herewith will enable the nature of this change to be realized more easily than a a mere description thereof.

Left lateral aspect of skull of *Iguanodon Bernissartensis* (Boulenger), from the Wealden of Bernissart, Belgium (much reduced). The anterior aperture in the skull is the nares (nostril), the middle one the orbit, and the large posterior one, the lateral temporal fossa.



Lateral view of skull of *Diplodocus longus* (Marsh), from the "*Atlantosaurus*" beds (Upper Jurassic), near Canon City, Colorado, N. America. ($\frac{1}{10}$ nat. size.)



Left lateral view of skull of *Ceratosaurus nasicornis* (Marsh), from the Upper Jurassic, North America. ($\frac{1}{8}$ nat. size. After Marsh.)

But this exchange, it is to be remembered, took place among many groups of reptiles, so far as the evidence goes, not in the least related. Among the Dinosaurs, for instance, the same transformation took place, and, similarly, the change was gradual. But while among the Pterodactyls the premaxillary teeth seem to have been the last to go, among the Dinosaurs, in many cases, these seem to have been the first to disappear. *Ceratosaurus* may well serve us as an example of what these creatures attained to in the matter of teeth, though even here, it will be remarked, the armature of the lower jaw is on the wane. And the same is true indeed of the upper jaw in so far as the hindmost teeth are concerned, but the decline is here less marked. In the giant *Diplodocus* all the teeth but a few skewer-like pegs in the front of the jaw have vanished completely, while in the *Iguanodon* the hindmost teeth are retained and the front teeth replaced by a beak-like sheath.

The Pterodactyls and the Dinosaurs were, however, as we have already remarked, not the only groups of these extinct Reptilia which, more or less completely, contrived to exist without teeth. Among these old "fish-lizards," the Icthyosauria, for example, a beautiful series in the reduction of the teeth is met with, ending with the jaws of *Ophthalmosaurus*, wherein the adult was toothless, or at most, in some individuals, retained but a few minute teeth confined to the front of the jaw.

From the reptile to the bird is an easy step; and one would expect the ancestral birds to have tooth-bearing jaws. In the earliest known bird, *Archæopteryx*, well-developed teeth are met with; and the same is true of the cretaceous *Icthyornis* and *Hesperornis*. But in the two last-named, both aquatic and fish-eating types, the toothless condition which was to prevail among modern birds was foreshadowed, inasmuch as the premaxillary portion of the jaw—the front portion of the upper jaw—was toothless and sheathed in horn. It would almost seem indeed as though these teeth were discarded grudgingly, at any rate among the fish-eating birds; since in another fossil—*Odontopteryx toliapicus*—though teeth are wanting the bony sides of the jaw developed tooth-like, angular bosses of bone which were encased in horn. And to this day certain fish-eating ducks adopt a similar expedient, though the bony cores to such horny "teeth" are wanting. Serrated edges to the beak-sheath are developed indeed among many groups of birds, some of which are certainly not fish-eaters. In the darter, which is piscivorous, teeth are replaced by short needle-like spines along the edges of the jaw, and a similar device obtains among the insect-eating sun-birds.

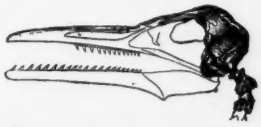
Since birds retain many vestiges of ancestral and now obsolete and discarded structural characters, it is but natural to suppose that some trace of the now absent teeth should appear in the embryo. According to some authorities such vestiges are to be met with in the embryos of parrots. But the evidence so far submitted does not bear out the interpretation placed upon it. Nevertheless it is highly probable that such evidence will yet come to light, and we venture to prophesy that it will be furnished by the tinamous and ostriches. The present writer, indeed, long since drew attention to certain toothlike structures in the jaws of young tinamous, and

hopes in the near future to demonstrate their true character.

Our survey has now brought us to the Mammalia, which in point of interest in this matter of teeth and their substitutes exceed all the other vertebrates.

Primitively tooth-bearing, some have now become absolutely toothless, as in the anteaters and echidna; while in others the number of the teeth has been greatly reduced. And this not by any sudden process, but as it were by slow starvation, each tooth as it passes the point of usefulness disappearing by a slow process of absorption. The last stages of their degeneration are carried out in secret as it were, the developing tooth being, so to speak, smothered before it cuts the gum. As a study in evolution by atrophy, it would be impossible to find a more striking series of examples than is to be furnished by the present day whales. Beginning with the Beluga, wherein this reduction is already far advanced, only

Skull and lower jaw of *Archæopteryx siemensi*, showing teeth, from the Lithographic Stone (Upper Jurassic) of Eichstadt, Bavaria. (Nat. size. After Dames. Original in Berlin Museum.)



Skull and lower jaw of *Ichthyornis victor*, from the Cretaceous of Kansas, U.S.A. (½ nat. size. After Marsh.)

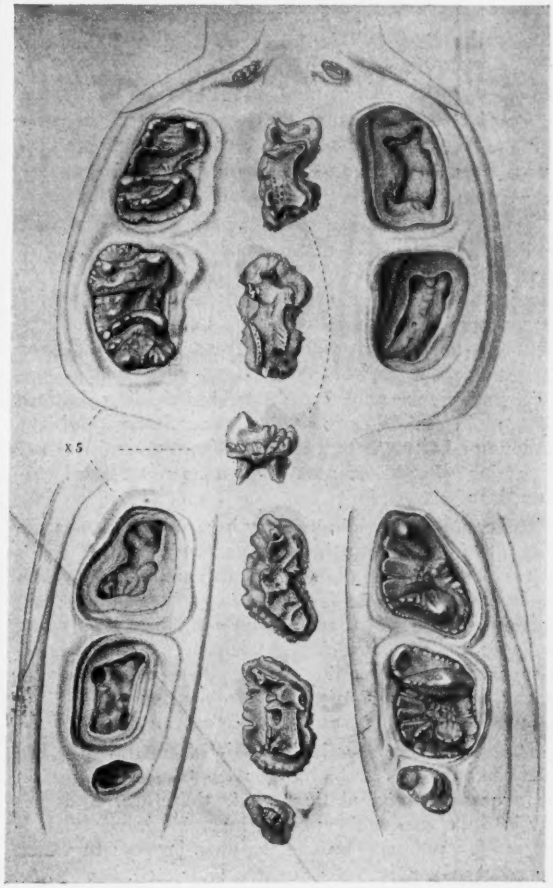
Skull and lower jaw of *Odontopteryx toliapica*, with bony denticles on jaws, from the London Clay of Sheppey. (½ nat. size.)

nine teeth remaining on each side of the upper and lower jaws, we pass to Grampus with from three to seven teeth in the lower jaw only, and thence to the Narwhal with but two in the form of the well-known tusks—generally only one of these is developed.

The whales again furnish us with one of the most extraordinary substitutes for teeth to be met with among the Mammals—to wit, the baleen-plates of "whalebone" whales. And it is therefore all the more remarkable that in this embryonic state the jaws contain their full complement of teeth, though these never cut the gum!

Finally, we come to the remarkable case of the Duck-billed Platypus (*Ornithorhynchus*). As is implied by its popular name, the jaws of this creature bear a very striking resemblance to the beak of a duck, though really much more flattened than in any Anserine bird. But, be that as it may, they are unquestionably bird-like, not only in shape, but in the absence of teeth. If the mouth be opened, however, there will be found within two pairs of saucer-shaped horny pads, attached to the upper and lower jaws respectively. These serve as crushing pads for the trituration of small mollusca on which the animal feeds; and, since the creature is a Mammal, these pads are obviously substitutes for teeth. So much, indeed, was always taken for granted. But in 1888, Professor Poulton, of Oxford, actually discovered teeth in the jaws of an embryo, and later Mr. Oldfield Thomas, of the British Museum, had the good fortune to discover these teeth actually in use in immature animals. He further showed that they remained functional till worn out, by which time the horny pads have grown large and hard enough to take their place!

The peculiarities of the teeth herein discussed have purposely been omitted, for these, as well as the manner



Palate of Duck-billed Platypus (after Poulton), showing the teeth in position, on the roof of the mouth (left-hand top figure), and in the lower jaw (lower figure, right-hand), the horny pads which succeed them show the sockets of the displaced teeth, seen, from their roots, down the middle of the picture.

of their use, seem to have no bearing on the law of survival. That is to say, animals of all grades, carnivorous or vegetivorous, show the same phases of evolution and devolution. But there seems to be some correlation between toothlessness and the persistence in time of the groups so denuded. Thus the earliest Dinosaurs, Ichthyosaurs, and Pterodactyls, like the earliest birds, all had the jaws armed with teeth, and all in course of time replaced these teeth by horny casements. And this seems to be true also of the Mammals, though to a less marked degree. It remains now for someone to read us the answer to this riddle.

XUM

India Rubber.

The Latex: Its Nature and Composition.

By HENRY P. STEVENS, M.A., Ph.D., F.I.C.

BEFORE we are in a position to discuss the methods of coagulating the Latex described in the previous article, and to discover exactly wherein the advantages of the processes lie, we must look closer into the physical and chemical nature of the Latex itself. The earlier work on this subject we owe to the late Dr. C. O. Weber, whose researches were carried out on the milk of the *Castilloa elastica* some four or five years ago.

Weber realised that any investigation as to the nature of the Latex must be carried out on the spot with the fresh juice. He found that a number of reagents, such as alcohol, brought about immediate coagulation.

Much work remains to be done before the exact condition in which the rubber is contained in the Latex is properly understood. Up to now the results of different investigators are not always in agreement. There appear to be great differences between the products obtained from different trees and at different stages of their growth.

However this may be, all rubber-yielding Latices contain in addition to the caoutchouc globules resinous and nitrogenous or protein matter and a small proportion of salts of metals such as potassium, calcium, iron, etc.

The caoutchouc globules vary in size in Latices from different sources. Thus the *Ficus elastica* (rambong) yields a Latex in which the diameter of the globules approach 3μ, in the Latex from *Hevea braziliensis* (Para rubber) the globules are on an average smaller, while the *Funtumia* and *Castilloa elastica* Latices yield globules on an average smaller still. There does not, however, appear to be any connection between the size of the globules and the general behaviour of the Latices.

The resinous matter in Latex is of considerable importance, as it is precipitated with the caoutchouc in the process of coagulation, and, therefore, finds its way into the raw rubber; being insoluble in water, it is not readily removed by the washing process to which the raw rubber is subsequently subjected.

Washed Para rubber, whether from the Amazon district or from the Eastern Plantations, contains 2-3 per cent. of resins, while the other varieties mentioned above may contain 5-7 per cent., or even more. The removal of the resins affects the behaviour of the rubber when it comes to be vulcanised and made up into manufactured articles.

Very little is known as to the chemical nature of these resinous substances, and the same is true of the nitrogenous or protein constituent found in all Latices. The latter is carried down, to a large extent, in coagulating the Latex, and is found to the extent of 2-4 per cent. in the washed dried rubber.

The inorganic constituents are left over on burning a sample of rubber to an ash; this, in the case of the best washed plantation rubbers, may amount to less than 0.1 per cent. From which it follows that the highest grade plantation rubbers may contain as little as three or four per cent. of foreign substances.

The coagulation of Latex may be brought about by a number of reagents, but they act differently on different Latices, and a substance such as acetic acid which rapidly coagulates *hevea* Latex has no action on *Ficus elastica* Latex. There are two stages in coagulation; the first stage, termed "agglutination," causes the globules to separate and float up to the surface leaving the mother liquor more or less clear underneath; on shaking vigorously the globules become distributed in the liquid, but slowly separate again on standing. This stage somewhat resembles the creaming of milk where it is, of course, the fat globules which rise to the surface. In the second stage, or coagulation proper, the whole of the Latex sets to a solid mass which usually shrinks together somewhat on standing, separating a clear watery liquor. The process resembles the effect of adding rennet to milk in making a junket. The rubber coagulum is, however, much tougher, stiffer, and more compact.

(*Copyright.*)

Young rambong (Ficus elastica) rubber tree.

Agglutination is not very often observed in the case of *hevea* (Para rubber) Latex under ordinary circumstances, as reagents which coagulate the Latex do not produce agglutination when added in smaller quantities. Thus considerably less than 1 per cent. of acetic acid, suitably diluted with water and stirred up with the Latex, causes it to set to a solid mass in a short time, but on reducing the proportion of acid we either get no effect at all or a little coagulation round

the edges of the containing vessel, or formation of clots in the mass. On the other hand, if the Latex be freed from soluble salts by means of dialysis addition of acetic acid produces agglutination only, and the mass does not coagulate until soluble salts have been added.* For practical purposes it is desirable to produce efficient coagulation with a minimum of coagulating agent, and therefore the study of the behaviour of the Latex to various acids and salts, which bring about or influence coagulation, is of the greatest importance, and as yet, perhaps, hardly sufficiently recognised. Unfortunately, hevea Latex will only keep fresh a few hours and cannot be preserved without the addition of powerful antiseptics such as formaline, which, of course, modify its reactions. It is, therefore, necessary to work with fresh Latex on the spot, that is, on the plantations in the tropics, where the investigator is at a considerable disadvantage. Some Latices such as that of the *Castilloa elastica* contain toxic substances, and in spite of the nitrogenous constituent they can be kept for long periods in ordinary stoppered bottles; this tree is, however, of relatively small importance in the East, where it has come to be recognised that wherever the hevea tree will grow it will pay much better to cultivate this than any other rubber-yielding species.

To return to the question of coagulation, the choice of coagulant and proportion in which it should be used must be considered, firstly, in the light of the effect, if any, produced by any residue of acid or other substance remaining in the coagulated mass on the properties of the resultant rubber, and secondly, on the microphysical structure of the coagulated mass.

In respect to the first point, it has recently been shown by Spence† that digestion of *Funtumia* Latex at a moderate heat for a long period with a very small proportion of a mineral acid has the effect of so altering the nature or chemical constituents of the Latex that the coagulated rubber has the peculiar "tacky" nature characteristic of rubber which has partially decomposed and deteriorated during transport. It would appear from this experiment that rubber from *Funtumia* Latex may deteriorate considerably in quality from residues of chemicals used for coagulation. As I have already emphasised, the natures of Latices from different rubber-yielding species vary considerably, and results obtained in experiments with one cannot be held without further investigation to apply to another; nevertheless, this is a subject which requires looking into as regards the Latex of the *Hevea braziliensis* in which English planters and English capital are largely interested.

As to the second point, it has been shown that the rubber from coagulated Latex has a certain structure, when microscopically examined, and this structure probably varies with the nature of the coagulant used. This matter has been much discussed, but is probably of little importance. It has been argued that the nature of this structure, which has been described as "reticulated," has or may have much influence on the strength and other physical qualities of the raw rubber. Even admitting this, the fact that rubber is never used in the raw state has been lost sight of. The mechanical processes to which the raw material is subjected, the grinding between steam heated and differentially geared masticating rolls would obviously break down and obliterate the original structure of the raw rubber, from which it follows that only those properties of the rubber which outlive this mechanical treatment are of any importance to the manufacturer,* and, further, a small fraction only of the mechanically treated rubber is used in the unvulcanised state. The process of mastication as just described is almost invariably followed by mixing with sulphur and other ingredients and heating to temperatures considerably exceeding 100° C., when the whole mass becomes soft and possibly semi-liquid and the caoutchouc enters into re-action with the sulphur. Under these circumstances it is unlikely that any definite structure should be preserved in the rubber. What has been said of this relatively coarse structure does not, however, apply to the original caoutchouc globule itself; we have no evidence of complete amalgamation of these in the process of coagulation, although when viewed under the microscope the globules in the process of coagulation do appear to heap themselves up and flow into one another. The matter awaits further investigation.

The rubber-yielding portion of the Latex, or the rubber itself, has been examined from time to time by several chemists. One of the first to analyse the crude rubber, in this case imported Para, was Faraday. I give below a number of analyses made by earlier workers taken from Dr. Weber's "Chemistry of India Rubber," to which I have added other analyses taken from recent literature, and for comparison's sake I give the theoretical composition of rubber assuming it to be a polymer of C_5H_8.

	Carbon.	Hydrogen.
Faraday	87·2	12·8
Ure	90·0	10·0
Williams	87·3	12·1
Berzelius	87·5	12·5
Adrian	87·91	11·94
Gladstone and Hibbert ..	87·46	12·00
Weber (purified Para)	87·91	11·86
Weber (ether ext. of Latex) ..	87·89	11·80
Harries (Ficus magnol Borci)..	86·99	11·98
Harries (Ficus elastica) ..	86·14	11·72
Calculated for C_5H_8	88·24	11·76

The Para was purified by Weber for analysis by fractional precipitation of a .1 per cent. solution in chloroform with alcohol. By this means he separated an insoluble constituent which had been examined by previous observers, in particular by Gladstone and Hibbert, who first showed the presence of oxygen in crude rubber. This insoluble constituent has always been more or less of a mystery. Weber, without sufficient experimental basis, declared it an oxygen derivative and even gave it a complex formula based on the percentage of hydrogen and carbon determined by analysis of the material isolated as described above. Spence, however, has recently shown that it contains a considerable proportion of nitrogen,† up to 5.4 per cent., equivalent to 33 per cent. of protein; that is to say, one-third of the insoluble constituent consists of organic nitrogenous matter derived, no doubt, from the protein in the original Latex, which, of course, would

* V. Henri.

† "Ueber einige einleitende Versuche zur Klarung der Ursache des Leimigwerdens von Rohgummi."—von Dr. D. Spence. Zeitschrift fur Chemie und Industrie der Kolloide, Band IV, Heft 2 und 3, 1909, p. 70.

* Beadle and Stevens. *Chem. News.*

† D. Spence. Distribution of protein in Para Rubber. "Journal of the Liverpool Institute of Commercial Research in the Tropics, 1907."

remain insoluble on treating the rubber with organic "solvents."

If crude india rubber be subjected to dry distillation, it yields half its weight of turpentine. It also yields a smaller quantity of an oil known as isoprene. This oil is very volatile and boils at the low temperature of 37° C. Isoprene shows the same carbon and hydrogen ratio as dipentene and the other terpenes and belongs to the group of substances with the formula $(C_5H_8)x$. Its boiling point being lower than that of dipentene its molecular weight, as is usual in such cases, is smaller, and x in this case equals one. It has been synthesized, that is, built up from simpler substances, so that we know its chemical constitution.

Under certain circumstances it undergoes polymerisation, that is, two or more molecules link up together with the formation of a substance which is said to have the peculiar physical properties of india rubber, and, indeed, to be actually india rubber produced synthetically. The whole question of synthetic rubber is, however, so beset with contradictory statements that it would be futile to attempt a discussion of the subject in the present article. In any case the quantities so far obtained appear to be very small indeed, and, being a colloid, it has no definite physical constants such as melting point or crystalline form by which small quantities could be identified with certainty. We can only preserve an open mind on the question until we have more definite data to go upon.

Timber Consumption in America.

IT has been estimated that the amount of wood annually consumed in the United States at the present time is twenty-three billion cubic feet, while the growth of the forest is only seven billion feet. In other words, Americans all over the country are using more than three times as much wood as the forests are producing. The figures are based upon a large number of State and local reports collected by the Government and upon actual measurements.

The State Forester of Connecticut, in a recent report, has given figures on growth and use for New Haven County, which give many more valuable details than are generally to be obtained, and well illustrate how the forest is being reduced by over-cutting. In this county a very careful study was made on each township of the amount of forest, the rate of growth, and the amount of timber used. For the year 1907 the timber used was 120,000 cords, in the form of cordwood, lumber, ties, poles, and piles. The annual growth on all types of forest land, including the trees standing on abandoned fields, for the year, reached a total of 70,000 cords. Thus the amount cut yearly exceeds the growth by 50,000 cords.

The amount of standing timber considered as merchantable and available for cutting within the next few years was found to be 1,200,000 cords. Each year the annual growth increases the supply on hand by 70,000 cords, while the use decreases it by 120,000. The net reduction is, therefore, 50,000 cords a year. If the cut and the growth remain at the present figures, the supply of merchantable timber will be exhausted in about twenty years. At the end of that time there will be a large amount of forest standing in the county, but it will be in tracts under forty years of age, containing wood below the most profitable size for cutting. Cordwood could still be cut, but supplies of the most profitable products, like ties and lumber, would be practically exhausted.

Connecticut's case illustrates what is meant when the exhaustion of the timber supply is spoken of. It does not mean that every tree will be cut and that the ground will be bare. It means, on the other hand, that year by year the people of the country are cutting more timber than the forest grows, and that within a comparatively short time the continued loss will have so reduced the forest that it will be difficult and expensive to obtain timber of useful size in sufficient quantity.

Venus as the Abode of Life.

By F. W. HENKEL, B.A., F.R.A.S.

OF all the heavenly bodies, the Sun and Moon only excepted, there is probably none of more interest to us than this planet. Approaching at times to a distance less than that of any other star, the great variations in its distance from us cause corresponding variations in lustre. Though many speculations as to the possible inhabitants of Mars and their supposed engineering works (the so-called "canals," &c.) have been mooted with more or less ingenuity, in our opinion the probabilities in favour of the habitability of Venus are vastly greater. This planet, says Professor Young, is "the Earth's twin sister in magnitude, density, and general constitution." Though its distance from the Sun is less than three quarters that of our own Earth (about 67,000,000 miles), varying only very slightly (its path being the most nearly circular of any known planet), and consequently any given area of its surface must receive about twice as much heat as we receive on an equal area, yet this is probably mitigated by the presence of a more extensive atmosphere laden with water vapour. From time to time different observers have deduced differing periods for the length of its day, but the most probable period seems to be about 23½ hours, or rather less than our own day. Its year (owing, of course, to its greater nearness to the Sun and its swifter motion) is only about 225 days, its speed in its path round the Sun being 23 miles per second. Its diameter is 7700 miles, whilst that of the Earth is about 7900 miles, so that the planet is slightly smaller, its mass (or quantity of matter) is rather over three-quarters that of the Earth, and consequently the average density of the materials composing it is 86 per cent. of the terrestrial density. A body dropped from a point near its surface would acquire a velocity of 27 feet per second at the end of one second, instead of 32 feet per second as here, and would move over 13½ feet during the first second of its motion. Surface markings have been seen from time to time upon the planet, more distinctly observed in Italy and other more favoured latitudes than our own. On account of its general proximity to the region of the sky in which the Sun is found, and its great brilliancy in the telescope, Venus is by no means an easy object to scrutinise with satisfactory results.

However, its phases or changes of appearance, like the Moon, are easily perceived with very small optical aid, and were amongst the first fruits of the invention of the telescope, exactly three centuries ago. Galileo, who first discovered that the planet exhibited the crescent phase and the other appearances presented by the Moon, announced his discovery in a curious anagram, which being interpreted read (in Latin) "The Mother of Loves (Venus) imitates the phases of Cynthia (the Moon)." The explanation of these phases is precisely similar to those of the Moon, and their appearance was a strong confirmation of the truth of the Copernian theory. Venus being an opaque body is visible only by the light which she receives from the Sun and reflects. The hemisphere turned towards the Sun is, of course, illuminated, the other side in darkness; more or less of the illuminated hemisphere being turned towards the Earth at different times. When the planet lies beyond the Sun, turning towards the Earth the whole of its illuminated hemisphere, it is seen (if not too close to the Sun's place in the sky) as a small round disc. Fig. 1 (4). When at its greatest elongation East or West of the Sun, about half the illuminated side is turned towards us and the planet is

seen like the Moon half full, but owing to its greater proximity appears half of a considerably larger disc than before. Fig. 1 (2). Near inferior conjunction, *i.e.*, where the planet is between Earth and Sun and on the same side of it, the planet is seen as a very thin crescent of large size, as it is then at its nearest to us. Fig. 1 (5).

The planet is brightest (to us) about 36 days before and after inferior conjunction.

From fig. 2 we may see the great variations in distance of this planet from the Earth—least at V_1 and greatest at V_3. Also, since at greatest elongation the angle EV_2S is a right angle, by observing the angle of elongation SEV_2

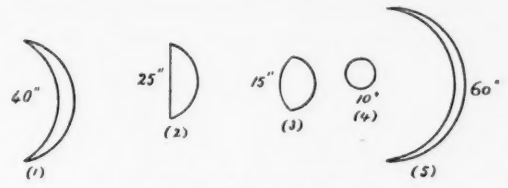


Fig. 1.—Phases of Venus.

1 and 5, near inferior conjunction; 2, at greatest elongation; 3, at gibbous phase; 4, superior conjunction.

we may find the proportion SV_2 bears to SE, or the ratio of Venus's distance from the Sun to the Earth's distance, for $\frac{SV_2}{SE} = \sin SEV_2$ and the angle of elongation SEV_2 is $47°$ $\therefore SV_2 = SE \sin 47° = \cdot 73$ (SE being taken as unity) or, as we have already stated, Venus's distance is rather less than three-quarters that of the Earth from the Sun.

From certain irregularities observed upon the terminator, or boundary of the limb, and the blunted appearance of one of the cusps of the crescent, various observers

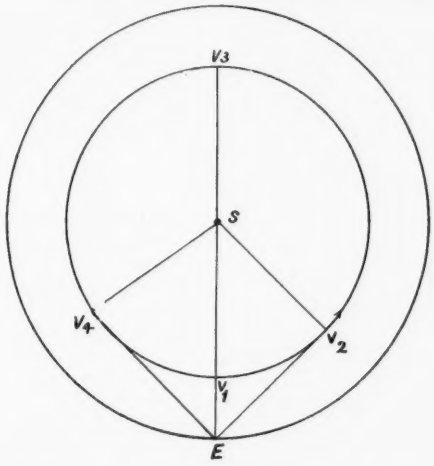


Fig. 2.

S, Sun; V, Venus; E, Earth; V_1, inferior conjunction; V_2, V_4, greatest elongations; V_3, superior conjunction.

have concluded that there exist high mountains upon the planet's surface. Sometimes when the planet is in the crescent phase intensely bright spots have been seen near the polar regions, which may perhaps be *ice-caps* like those seen on Mars. Darkish markings, indicating continents and seas "dimly visible," are also at times seen, and a rough map of Venus was made by Bianchini long ago. His observations were confirmed by thousands of observations made by De Vico and his assistants, so may be considered to represent real features of the surface.

We have already stated that there is evidence of the existence of an atmosphere, and from observations of the transit of the planet across the Sun's disc in 1874 it was concluded that the atmosphere is about $1\frac{1}{2}$ times to twice as extensive as our own. The existence of water vapour has been shown by the spectroscope.

At times the dark portion of the planet, unilluminated by the Sun's light, has been faintly visible, from which it has been considered probable that phenomena of the nature of the Auroræ take place from time to time upon Venus. So far as known, the planet has no satellite or moon attendant upon it, but to a great extent the want of a moon is made up for, to the possible inhabitants, by the Earth. When Venus and the Earth are nearest, as we have already said, they are on the same side of the Sun, and the planet turning its dark side toward us is invisible, like the Moon when new. On the other hand the Earth has the whole of its illuminated side turned towards the planet, is on the opposite part of the sky to the Sun, and is consequently visible as a brilliant object ("Full Earth") in the night sky of the planet. We know from the phenomenon of Earth-shine that the Earth reflects a considerable quantity of light to the Moon, part of which is again reflected back to us, and if we suppose the intrinsic reflecting power of the Earth's surface to be equal to that of Venus (it may indeed be, and probably is, considerably less) it must give much greater light to the planet and be a much more brilliant object in its sky than Venus ever appears to us, owing to the following circumstances. When brightest only a small part of the planets'

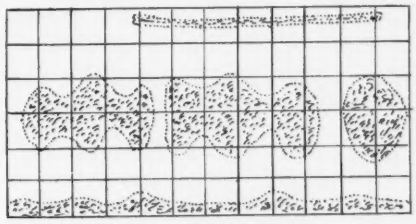


Fig. 3.—Bianchini's Map.

illuminated surface is turned towards us, but even so it appears more conspicuous than any other star or planet in our sky, and is often visible in daylight. On the other hand the *whole of the Earth's illuminated hemisphere is turned towards Venus* when they are at their nearest together, and the Earth is then on the meridian at the planet's midnight, being in "opposition" to the Sun. Thus as a night luminary the Earth to some extent plays towards Venus the part the Moon does for us.

Occasionally Venus passes directly between the Earth and the Sun at inferior conjunction, and is seen projected as a black dot on the Sun's surface crossing it from east to west, sufficiently large to be visible to the unaided eye. Ordinarily, owing to the fact that the plane of its path is inclined at a small angle ($3\frac{1}{4}°$) to the plane of the ecliptic (Earth's path), it passes a little to the North or a little to the South of the Sun's place. These transits across the Sun's surface have a special interest for astronomers, owing to their affording an opportunity for determining the Sun's distance from the Earth with great accuracy. Accordingly expeditions have been made to distant parts of the Earth to observe these transits when they occurred. The transit of 1769 was observed by Captain Cook at Otaheite, he having been sent by the Government of that date to the South Seas at the request of the Royal Society. The transit of 1882 was visible in this country,

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and was also observed in various other parts of the world. When Venus passes between the Earth and Sun she is at her nearest to us—between three and four times nearer than is the Sun. Consequently, as seen from different parts of the Earth, Venus will be seen to cross different portions of the Sun's disc, and by exactly determining the planet's path as seen at the different stations whose distance from one another is known, it is possible to determine both the planet's and the Earth's distance from the Sun. In Halley's method two stations at which the transit is visible are chosen, the stations being one as far *North* and the other as far *South* as possible. The duration of transit (*i.e.*, the time occupied by the planet in crossing the Sun's disc, is observed at each station, and

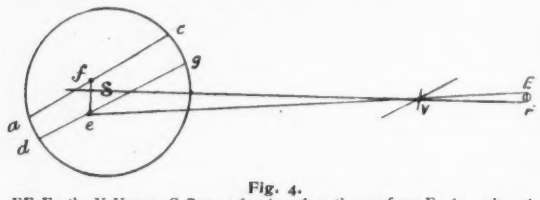


Fig. 4.
EF, Earth; V, Venus; S, Sun; *a f c*, planet's path seen from F; *d e g*, planet's path seen from E.

knowing the planet's velocity in its path, the length of the chords *a f c*, *d e g* is known, the displacement *f e* being the measure of F E at the Sun (while from the similar triangles E V F, *e* V *f* we shall also get E F : *e f* : : V F : V *f*, &c.). (Fig. 4.) Knowing the ratio of V F to V *f*, and the distance E F, all the other distances may be thus easily found (in miles, &c.).

There are, however, practical difficulties in the way of determining the *exact instant* the planet enters and leaves the Sun's disc, different observers having obtained differences of about 10 to 15 seconds of time, though observing side by side. The atmosphere of Venus causes its edge to be more diffuse than would otherwise be the case, and the phenomenon of the black drop, at internal contact, also complicates matters. Instead of touching sharply, a kind of ligament or "black drop" extends from the planet to the Sun (fig. 5), a similar effect to that which is observed when we bring two fingers in contact and then hold them up to the light and separate them; as they separate a "black ligament" will appear to connect them for a short space. By means of photography it was attempted to render the results more certain; but so far the photographic methods give no better satisfaction than the others. It is now generally considered that the transit of Venus method, though admirable in theory, has proved of less value than was expected, in practice, and by the time the next transit comes round (there are no more till 2004 A.D., nearly a century hence) other methods are likely to have given better results.

Fig. 5.

We have seen that there is evidence of the existence of continents and seas, air, and water vapour upon the planet. The amount of sunlight it receives, though greater than our share, is not excessively so, for there appears reason to believe that polar snow-caps exist, and in other respects, for conditions favourable to the existence of beings organized not very much unlike those with which we are familiar on this Earth, we have as much evidence as we can reasonably expect. We may thus conclude that the planet is in most respects not dissimilar to the Earth, and is the abode of life, at least in the regions north and south of the Equator, if not on the "torrid zone" itself.

Notes on the Sclerenchyma Ring in the Stem of the Sycamore

(Acer pseudoplatanus) and other Species of Acer.

By JOHN HUME.

IF a transverse section be examined of the stem of the Sycamore (*Acer pseudoplatanus*) which has been cut from the tree in the winter there will be found a continuous sclerenchymatous ring in the cortex surrounding the vascular portion, and this ring is so continuous in stems of considerable age, even up to six and seven years, after which irregular bundles of bast fibres appear in the secondary bast.

The question then arises as to how this ring increases in circumference each year to accommodate the increased diameter of the contained phloem and xylem.

For the purpose of ascertaining this stems were cut in the early spring just when the leaves were fully expanded and the tree was in vigorous growth.

Sections prepared from these stems showed that the new sclerenchymatous cells are developed from cells from the cortex both within and without the ring. These cells force their way between the original bast fibres, tearing them apart and filling up the space they have opened, continuing to grow in size and in many cases to rapidly divide into a number of new cells.

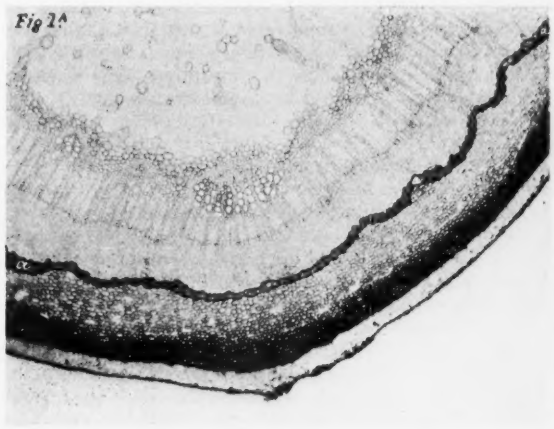
The original entering cells, or those produced from them by division, then become very thick walled and pitted, and by the autumn have become an integral part of the then again continuous ring.

The ring becomes very little if any broader, practically the whole of the increase being in its circumference. In the autumn of the first year it consists almost wholly of bast fibres very regularly placed, but the additional cells added each year are very irregular both in size and shape, though generally being about equal in diameter in each direction, similar to the cortical cells from which they have sprung. De Bary* in writing of the changes which take place outside the cambium layer during increase in thickness says :—

"If on the other hand, as is in fact often the case with the sclerenchyma, they form closed annular layers, the latter are burst. The severance of connection then takes

* "Comp. Anatomy of the Vegetative Organs," p. 543.

place through the limiting surfaces of the elements. As soon as this begins at any point of the external surface of a sclerenchymatous ring, neighbouring parenchymatous cells bulge out and insert themselves into the gap, which they fill up. They then either maintain the properties of parenchymatous cells growing and dividing in proportion to the increasing width of the gap owing to progressive growth in thickness, or they undergo the sclerenchymatous metamorphosis immediately upon their insertion; the original ring becomes completed by interpolated short stone elements as described above."



The above observations confirm these remarks with the exception that the cortical cells have been shown to grow into the sclerenchymatous ring both from the internal and external surfaces, and not only from the external surface alone as De Bary states.

Fig. 1 is a photograph of a transverse section of a one year old stem cut in the late autumn, in which the continuous sclerenchymatous band is shown at (*a*), and with the aid of a lens will be seen to be composed almost entirely of bast fibres, the remainder being thick walled sclerenchymous cells.

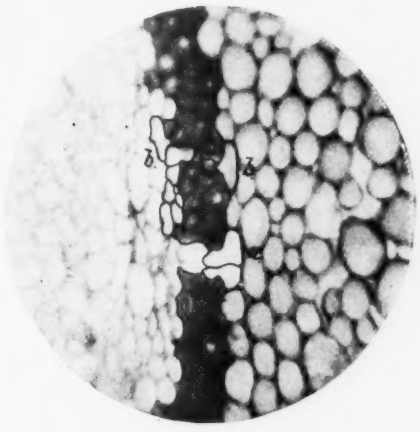


Fig. 2.

Fig. 1*a* is from a similar section, but photographed under different conditions to bring out more prominently the band.

Fig. 2 is from a transverse section of a stem cut in the early spring in which at (*a*) cells from the outer cortex can be seen forcing their way between the bast fibres, and again at (*b*), where they are entering from both sides. At this point the way in which the bast fibres have been fitted together is well seen.

Fig. 3 also shows similar cells breaking through the ring from both sides at (*a*) and (*b*), and at (*c*) can be seen a bast fibre almost isolated from the remainder.

In fig. 4 several cells have grown into the ring at (*a*), and have commenced to thicken strongly in places.

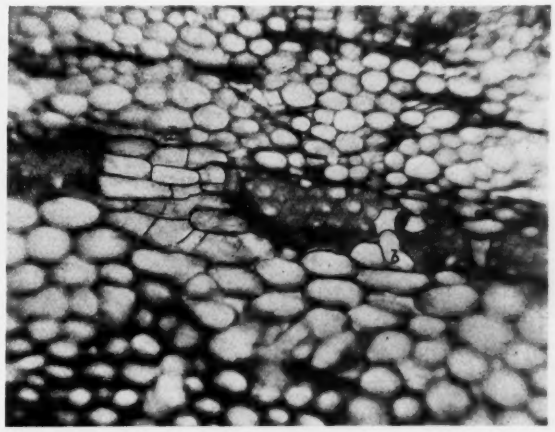


Fig. 3.

Turning again to fig. 3 at (*d*) and fig. 5 at (*a*) are groups of cells rapidly dividing. These cells form sclerenchymatous cells, and a group of such irregularly thickened cells can be seen at the termination of a medullary ray in fig. 1 at (*b*). Such large groups of cells are generally found approximately opposite to the ends of medullary rays although divided from them by the cortical cells.

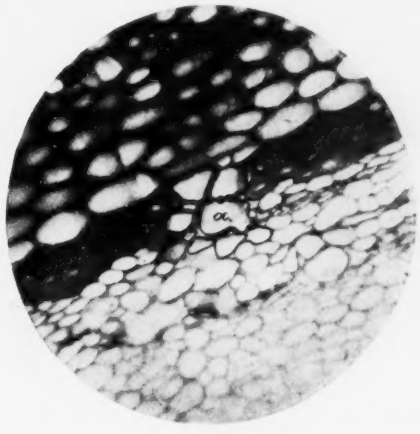
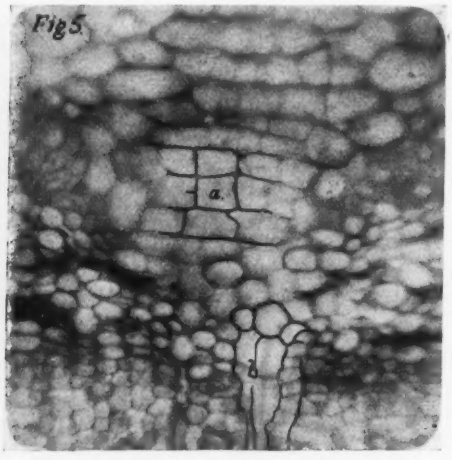


Fig. 4.

Fig. 6 is a photograph from a transverse section of a seven year old stem cut in the winter and shows two groups of bast fibres at (*a*) and (*b*) with some large deeply-pitted and very thick walled sclerenchymatous cells (*c*) which have grown in between them. The difference in the character of the two kinds of cells is particularly well displayed in longitudinal sections in which the bast fibres are of considerable length whereas the sclerenchymatous cells have the same appearance as in the transverse

sections. Solereder*, in describing the species of Acer' says:—

"The varied structure of the pericycle is very noteworthy. In *A. negundo* a composite and continuous ring of sclerenchyma is found in this region, in *A. pseudoplatanus* a somewhat interrupted composite ring; in other species investigated (*A. platanoides*, *A. campestre*, *A.*



spicatum, *A. distylum*) as well as in *Dipteronia* only isolated groups of bast fibres occur. The secondary bast in *A. campestre*, *A. pseudoplatanus*, and others, as well as in *Dipteronia*, contains bundles of hard bast, which occasionally give rise to stratification of the ploem."

With regard to his remarks on *A. pseudoplatanus* the specimens have evidently been taken during the spring

Fig. 6.

or summer, when the ring appears somewhat broken owing to the growth of the interpolating cells, whereas in the late autumn and winter the ring is quite continuous as the photographs show. Observations made on specimens cut in the winter of *A. platanoides*, *negundo*, and *spicatum* confirm his remarks on these species.

* "Systematic Anatomy of the Dicotyledons," Vol. I., p. 239.

A Botanist's Cycling Tour.

By GEORGE TALBOT, F.E.S.

THE machine which carried me on this excursion was fitted with two large carriers. At the front was strapped a leather valise and a waterproof cape. The valise contained a spirit lamp and other adjuncts to a light meal in the open. Behind there was fastened a bundle of underclothing done up in American oil-cloth; also a large tin box for specimens. A haversack contained books and botanical apparatus. Thus equipped I set out from Southampton on a certain July morning. The route lay through Romsey and over some hilly country on the edge of Salisbury Plain. Farther on, through the beauties of Savernake Forest, I reached Marlborough in the evening by a very steep and long descent on the edge of the Downs.

Leaving Marlborough at 6.30 next morning, I traversed a desolate expanse of Down country. The peculiar rounded billowy hills stretched away into the distance on all sides and ahead, the white road, showing up against the dark green verdure, could be seen emerging from the dips and crawling up the hillside in its switchback undulation. Along its border I met for the first time large quantities of the fine purplish-blue *Geranium pratense*, and onwards, as far as Shropshire, I frequently caught sight of this flower. The roadside was also gay with large clumps of the Nodding Thistle (*Carduus nutans*,) its rich purple flower-heads depending obliquely after the manner of campanula. Then there was a profusion of the yellow Lady's Bedstraw (*Galium verum*,) the Sheep's Bit Scabious (*Jasione montana*), Devil's Bit (*Scabiosa succisa*), and Rock Rose (*Helianthemum vulgare*). The luxuriance of these plants showed them to have found a fitting habitat on the bare chalk Down. There was a fine run down into Broad Hinton, where I breakfasted on choice Wiltshire productions. At noon I reached Cirencester, and then over the Cotswolds to Cheltenham. Continuing in a drizzling rain, I crossed the Severn at Tewkesbury, and so to the wooded Malvern Hills and into Hereford, where I halted at the quaint town of Ledbury. Next day Bishop's Castle was reached at 8.30 p.m. After a good night's rest I looked out upon a dull crepuscular morning and drizzling rain, into which I plunged at 2 p.m. After a few hours of uninteresting progression I entered the mountains, and the scenery became very picturesque. To the right there rose the steep mountain-side, its upper part bare and rugged, the lower gay with a multitude of foxgloves, blue scabious, and yellow hawkweed, all showing up against a background of green fern and moss. Here and there rills and torrents gurgled and roared down rocky gulleys to pass under the road and over a precipitous slope to the river which, hidden by trees, could be heard roaring over its rocky bed far below. Beyond rose mountains as far as one could see, their peaks and ridges obscured by cloud-banks that moved up the higher valleys. It was a sublime scene under the heavy sky, for the night proved wet and stormy, and the dark larch-covered lower slopes added to the general effect. I reached Cemmes Road in the Dovey Valley at 9.45. There is a little station here, a few cottages, a few houses, and a solitary hotel where anglers are wont to congregate, and in which I passed the night very comfortably. I was awakened by the trains at the little station opposite, and looked out upon a dull sky with pouring small rain. This forbade cycling to Barmouth, so I took the first train there. At Aberdovey, away from the mountains, there came brilliant sunshine, and a fine

blue sky stretched away seawards over Cardigan Bay, whilst a balmy refreshing breeze swept over the water. Back up the Dovey Valley the mists still tarried.

Mounting the machine at Barmouth, I pedalled slowly along the hillside and up the coast past Llanbedr and Harlech. The warm and brilliant afternoon brought into activity numerous butterflies which hovered over the profusion of flowers that decorated both sides of the road. Here was the ubiquitous foxglove in great luxuriance, and maintaining in the dampness an equal supremacy with the tall yellow Hawkweeds (*Hieracium*) which loved the drier rocky crevices. Along with these grew quite a multitude of *Scabiosa succisa* and *Jasione montana*. The curious *Cotyledon umbilicus* with its spike of yellowish-green flowers favoured greatly the crevices of the wall along the edge of the cliff. Here also was a luxuriant growth of fern, including the *Asplenium felix-fœmina*, *Polypodium vulgare*, *Aspidium aculeatum*, *A. felix-mas*, and *Blechnum spicant*. On the wall itself, the elegant *Asplenium trichomanes* spread its delicate fronds chiefly on the sea aspect, and on top of the wall the tufted and tougher fronds of *Asplenium ruta-muraria* were scarcely ever lost sight of.

Wheeling slowly past the ruined Harlech Castle, I looked towards Portmadoc across the blue waters of Cardigan Bay to the distant heights of Snowdonia, their peaks wreathed in grey mist with dark ominous clouds above. Away to the left the sun lit up the blue-green sea now gently disturbed by a breeze into long ripples stretching far away up the line of sandy coast. Late in the afternoon I entered the mountains on the Beddgelert road, made tea in a fairy-like dale below a foaming waterfall, and botanised amongst the luxuriant vegetation to much advantage. The aromatic Bog Myrtle (*Myrica gale*) flowered profusely in swampy ground in the dale, and here also were clumps of Asphodel (*Narthecium ossifragum*) and Marsh Orchis (*O. latifolia*). Nestling among the low herbage was the round-leaved Sundew (*Drosera rotundifolia*), and with it the *Galium palustre*, *Lotus uliginosus*, and *Pedicularis palustris*. Along the roadside the fragrant *Spiræa ulmaria* was common, and in fact I had traced this plant all along from Gloucestershire. The deep yellow flowers of *Melampyrum sylvaticum* were common here in shady places and also the *Potentilla verna*, whilst of frequent occurrence were the St. John's Worts *Hypericum dubium* and *pulchrum*. The white star-like flowers of *Sedum anglicum* showed up against the green moss covering walls and rocks.

Once more mounting the machine I entered the pass of Aberglaslyn, and at 7 p.m. reached the village of Beddgelert, nestling amid trees and surrounded on all sides by high mountains. Few sounds disturbed the tranquillity of this scene with its rich green pastures where the black Welsh cattle lived their lazy time. Away from the central part of the village one hears simply the dull murmur of mountain brooks, a few notes of birds, or the shepherd calling loudly to his flock. Over all there breathes the solemnity of the mountains, and this changes in mood with the fluctuation of rain and cloud.

Leaving at 7.30 next morning, my route led through the Nant Gynant, a narrow glen down which the Glaslyn murmured its way to Beddgelert. I stopped beside a waterfall and breakfasted, and from this point of vantage could take in much of the picturesque Nant Gynant, which has few rivals even in Switzerland itself. Slowly moving on again I reached the Pen-y-gwryd Hotel. Here the road bends to the left and is much steeper until one comes to the Corphywsfa Hotel at an elevation of 1179 feet. Here I left the machine and commenced the Snowdon ascent at 11.30 by what is known as the lower Capel Curig path. The distance to the summit from here is four miles. After passing Lakes Teyrn and Llydaw I reached the source of the Glaslyn at the lake of that name. The Snowdon peak rises precipitously from here, with lesser peaks all round. I observed a plenitude of *Saxifraga stellaris* and *Pinguicula vulgaris* growing among the wet rocks. The foxglove occurred sparingly lower down, and many a solitary hawkweed raised its yellow head. The characteristic vegetation was moss and lichen. The club-moss (*Lycopodium selago*) grew commonly in large tufts, and the *L. alpinum* spread its hard creeping stem over the moss-covered rocks to a length of perhaps two feet. In damp crevices large clumps of Parsley Bracken (*Allosorus crispus*) were conspicuous. From Lake Glaslyn there is a fairly stiff climb of about 1500 feet to the summit up a rocky zig-zag track that is not always easily discernible. I eventually lost it completely and found myself botanising near a torrent—the Pant-y-Lluchfa. I was rewarded with *Saxifraga hypnoides* and *Pinguicula vulgaris* in flower. A thousand feet lower this latter plant was in fruit only. I eventually struck the path again and reached the top soon after 2 p.m. Here the enveloping clouds were rather thick, and a fierce, cold wind swept over the ridge. I climbed the cairn of stones and ate some sandwiches, enjoying at brief intervals the effect of wonderful views appearing to be projected on a white screen, as the veil drew aside here and there from time to time. At about 4 p.m. the clouds suddenly cleared off, disclosing a glorious panorama. All around were peaks and billowy mountains and green valleys, in which many lakes glistened under the bright sun. The villages were hidden away in the dales, and the whole country appeared desolate, though lovely. Anglesey and the Menai Strait was plainly visible, and far beyond in misty outline the Isle of Man. One could trace, too, much of the North Wales coastline. Above there was the blue empyrean, and it was a shock to see the clouds come up as if from nowhere and once more effectually blot out the panorama and the sun. I made a rapid descent by the way I had come, and reached the hotel in 1½ hours. A little later I was spinning down through the rugged pass of Llanberis, and a cross-country route brought me to Bethesda at 9 p.m.

Set out about 9.30 next morning for Bettws-y-Coed. The way led up the Nant Ffrancon to Lake Ogwen, nearly 1000 feet above sea-level. Several interesting plants were gathered in this neighbourhood. These included *Saxifraga stellaris*, *stellaria uliginosa*, *Veronica montana*, *Asplenium lanceolatum*, and a species of large Liverwort which was parasitic on a moss that grew on a rock. I spent the afternoon in the woods by the Llugwy and gathered *Senecio aquaticus*, *Serratula tinctoria*, *Sanicula europœa*, and *Vaccinium myrtillus*. After tea in a cottage I set out at 6 o'clock on an eight miles walk over the moor above Bettwys. The track is an old Roman road called Sarn Helen, which ran from South Wales to Conway. The elevation is about 900 feet, and here for the first time I came upon the very graceful Ivy-leaved Campanula (*Wahlenbergia hederacea*) in abundance on the damp pasture. Intermixed with it was the equally beautiful *Anagallis tenella*. The bogs were rich in the Round-leaved Sundew, in yellow Asphodel, and Marsh Orchis, the latter in such profusion as I have never seen before. The Butterwort (*Pinguicula vulgaris*), now in seed, was conspicuous by its luxuriant rosette of fleshy leaves whose sticky margins held the small insects that happened to crawl upon them. Waving tufts of cotton grass (*Eriophorum angustifolium*) was a sure indication of boggy ground. Here and there in bare spots the red Bog Lousewort (*Pedicularis palustris*) was another

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plant peculiar to these moors. On the drier moor grew masses of the *Erica cinerea*, and in places *Orchis incarnata*, the narrow-leaved form of latifolia. I made for the Pant-y-pant road in the Llydr Valley and so back to Bettwys-y-Coed.

The following day, after visiting the Fairy Glen and Conway Falls, I proceeded to Penmachno, a quaint village inhabited chiefly by quarrymen. A hedge along the road leading to it was composed of *Spiræa salicifolia*, whose white blossoms tinged with pink were just opening. After tea I crossed the Machno and began the ascent of the mountain which separated me from the village of Dolwyddelen in the Llydr Valley. The climb was none too easy over a rough boggy ground to about 1400 feet. The bogs were yellow with Asphodel and green with Sphagnum moss, but not a single Orchis could be seen, a strange contrast to the moor beyond Pant-y-pant. The drier parts supported a species of *Polytrichum*, which seemed the dominant moss. On damp grassy pasture high up, the fine variety *lutea* of Viola tricolor was of frequent occurrence. Eventually reaching Dolwyddelen I took train for Bettwys. Presently the sun began to sink down amongst the hills, presenting a lovely scene as its departing rays shot through the purple gossamer that filled the valleys. I caught a glimpse of a rose-coloured sky paling into amber as the train rounded the curve into the gloom of the Llydr Valley.

Next day I once more resumed the saddle and left Bettwys for Llangollen. Reached this place in the afternoon in pouring rain, and spent the evening indoors dissecting specimens. Next morning a five-mile walk over the mountain yielded little of note except perhaps *Geranium pyrenaicum* and lower down the *Geranium columbinum*. I set off for Shrewsbury at 2 p.m. in splendid sunshine, and reached there after a hot and uninteresting ride of 32 miles. Thence I took the London road to Wenlock and brought up at Bridgnorth at 8.20 p.m. The following day I reached Banbury *via* Stratford, and near the former place found *Sedum reflexum* on limestone. Another day brought me into Middlesex and concluded the tour. The machine had been fitted with a new pair of Palmer tyres, and the tour was finished without a single puncture being sustained, although many rough and flinty roads were encountered.

Cellite.

ALTHOUGH celluloid possesses several of the same constituents as guncotton, not very many accidents result from its inflammability. But it has dangers, and in one aspect of its use—as a cinematograph film—celluloid has been responsible for more than one serious disaster. The celluloid film may be exploded into flame by contact with nothing hotter than a glowing ash, and accidents have resulted when the heat of the projector lantern is badly focussed and heats the film as a "burning glass" would do. In such cases an exposure of three seconds to heat of this kind has produced inflammability and a dangerous accident. For eleven years past the chemists of a factory at Düsseldorf have been making investigations with a view to combining the chemical constituents of celluloid in such a way that they shall be less dangerous when exposed to heat, and according to M. Lemaire these researches have been so far successful that in "cellite" a substance has been produced which can be adapted to all the purposes of celluloid, and which burns only with difficulty and slowly. A special form of "cellite" is made for cinematograph films. In appearance it is not distinguishable from the celluloid film. It is not actually incombustible, but it takes fire reluctantly, and the flame travels slowly. Generally the most that happens is that heat or a light will melt the greater part of the film merely as if it were sealing-wax. The liquid thus formed running off removes the flame from the rest of the film, and the conflagration simply goes out.

A Prehistoric Norfolk Trackway.

By W. G. CLARKE.

IN a county of which two-thirds of the parishes have yielded remains of the Neolithic or Bronze stages of culture it is highly probable that there was a large number of prehistoric trackways, which in the more thickly populated areas are now in use as metalled roads, with all trace of their early origin lost. Only in the more barren districts, where many of the bye-roads are little altered since they first came into use as channels of communication for a stone—or bronze—using folk, is it possible to assert with any degree of probability that any particular track is undoubtedly prehistoric. There are good reasons for believing this to be the case both with the Icknield Way and Peddar's Way, which crossed somewhere on Roudham Heath, a few miles north-east of Thetford. A much shorter road, and one little known, also ends on Roudham Heath, where it unites with Peddar's Way, its course of some fourteen miles connecting this extremely ancient way with the fen land at Hockwold. For eleven miles it is still the unmetalled heath track, giving vistas of miles of heather and bracken, of straggling "belts" of larch, beech, or pine, or of stone-covered "brecks," though at one point it overlooks several reaches of the river Little Ouse, with its bordering marshland, and also passes near four of the remarkable meres on which nest many of the rarest ducks on the British list. Its western termination is at Blackdyke, Hockwold, on the "skirt" land which borders the great fen plain, and it seems certain that the earliest peoples who used it arrived at this point in coracles or dug-outs from the islets in the fens, or the high ground on its borders. Close by the Way, in the gardens of Hockwold Hall, is the base of a mediæval cross, and not far distant, in the adjoining village of Wilton, still stands a stone cross 15 ft. in height, rising from a pedestal 4 ft. in height. The ancient Way now forms the main street of the village, and for over two miles eastward the road is still metalled, about midway passing through a gap in the "Devil's Dyke" or "Fen Dyke," a ditch and rampart—the ditch on the west—connecting the marshland of the Little Ouse with that of the Wissey, and said by tradition to have been formed by the devil trailing one leg on the ground, the huge Castle Hill at Thetford being the scraping from his boot. In Weeting village the highway has been diverted, and part of the vicarage built thereon, but a footpath still marks the ancient and more direct Way.

Eastward of the inhabited portion of Weeting the ancient track is known as "The Drove" or "Harling Drove," proof, with the Northumberland "Drove Way" and the Surrey "Drove Road," of its use as a means of bringing flocks to the mediæval sheep-fairs. After crossing a small brook, the only stream on its course, it passes a huge poplar-crowned barrow known as "Pepper" Hill, said to be so called because from its summit Oliver Cromwell "peppered" Weeting Castle, a mile away! Then, for a mile, by deep-rutted turf or over wastes of sand, it climbs the long slope of Bromehill, from the top of which Ely Cathedral may be seen 16 miles across the fens, while the red-tiled roofs of Brandon cluster among the trees on the Suffolk slope of the Little Ouse valley. This ridge abounds with prehistoric remains. Leaving out of account the paleoliths found beneath boulder clay at Botany Bay, Weeting, and the hundreds of beautiful specimens from the so-called river-drift at the southern foot of the hill, as belonging to a period when the land-surface was vastly different, a mile to the north are the vast Neolithic flint-workings at Grimes' Graves with an

abundance of white-patinated flint implements in the vicinity, while the surface of the eastern, western, and southern slopes of the ridge is strewn with thousands of chipped—and occasionally polished—implements of the Neolithic Age. Many of them are superbly worked, and few other areas of like size in England have yielded so many relics of prehistoric man. On the eastern slope of Bromehill the "Drove" cuts through an old plantation, at the foot of which for a couple of hundred yards its course is a sandy desert, with an abundance of flints, practically all of which show signs of human workmanship. Here the track is closely approached by a northern bend of the Little Ouse, and this must have been the most important point on its entire length. Evidence of this is furnished by the huge earthen banks which run from Grimes' Graves to the marshland, by the astonishing number of flint implements lying on the surface, and even more so by the fragments of pottery and the abundance of "pot-boilers," which denote a lengthy occupation.

That the "Drove" was also a Roman way, though never a made road, is proved by the intermixture hereabouts of Castor and Upchurch ware with the rougher quartz-besprinkled potsherds of the Bronze or Neolithic Ages. A denarius of Valens was also found on Wilton Heath and in a gravel pit in the same parish a gold cross with a medallion in the centre bearing effigies of the Emperor Heraclius the First and his son Heraclius Constantinus was also disinterred. It is one of the most beautiful specimens of Byzantine art found in the Eastern counties. Near the Blackdyke end of the "Drove" a Roman urn containing a number of coins was found some years ago, and is now in the possession of Mr. Cole Ambrose, of Stuntney Hall, Cambridgeshire, while in Santon parish, to the east of Bromehill, old maps mark a "Caldecot," which may indicate a rough shelter providing sleeping accommodation only, which was used in Roman times.

In Santon parish the "Drove" is a mere sandy trackway in a region of extreme desolation (a "sand-ton" the parish is in very truth), here and there bounded by earthen banks of uncertain age. After crossing the highway between Thetford and Mundford, an even wilder district is entered, where the hundreds of acres of bracken, the dismal-looking pine plantations, with the track in places almost lost among the encroaching heather-tufts, make a realisation of the primeval aspect of the Way by no means difficult. The calls of the heathland birds—the shrill whistle of the stone curlew, the plaintive pipe of the ringed plover, or the melancholy note of the lapwing—add to the eeriness of the scene. Leaving West Tofts Heath the parish of Croxton is entered, and here there are big boundary banks, while a proof of the great antiquity of the "Drove" is provided by the highway from Stanford, which runs into the "Drove" and then turns almost at right angles for about fifty yards before its junction with the Watton-Thetford highway. Had the latter been the older it seems certain that in such an open country the Stanford road would have run directly into it, and so have avoided an awkward angle.

Thence for half a mile the "Drove" is bordered on the north by a wildling hedge, the only one on its heathland course, the adjacent fields all having the Norse "Grimmer" in their names—"Grimmer's Breck," &c. A little to the south of the track is a fine barrow known as "Mickle Hill," close to which a few years ago was found a Teutonic bronze mount of the 4th century, A.D.—one of five of the kind found in England—which is now in Norwich Castle Museum. The road then runs on the narrow ridge between the Devil's Punch Bowl mere and Fowlmere, the former a small crater-shaped hollow, and the latter a more shallow depression some eighteen acres in extent when full of water, though these heathland meres are subject to remarkable fluctuations of level, and at varying intervals are quite dry, when the bed of Fowlmere is usually cultivated and yields good crops. Across further far-stretching heaths, the "Drove" is a parochial boundary between Croxton and Wretham, and furnishes extensive views. On the "brecks" adjoining the trackway here, as all along its course, there are abundant relics of the workmanship of Neolithic man, and both by Fowlmere and Langmere—the next mere to be reached—there appear to have been permanent settlements. Between the two meres my finds have included a stemmed and barbed arrowhead, and by Langmere a flint saw of superb workmanship, having 32 teeth on a length of 1½ ins. Langmere is the wildest and dreariest of the meres near the "Drove," and is consequently beloved of wild-fowl, being a breeding place for mallard, teal, gadwall, shoveler, garganey, pochard, and tufted duck, though perhaps not all in one season. A knoll on the southern side of the mere is crowned by about a dozen fir trees, which are traditionally said not to have been planted by the hand of man. On the other side of the "Drove" is a circular, crater-shaped hollow, known as Ringmere, which, during a dry period nearly 200 years ago, was described as a Roman amphitheatre.

On the adjoining heathland a great battle was fought between Saxon and Dane in the May of 1010, the latter proving the victor. The men of Norfolk and Suffolk fled, the men of Cambridgeshire—some of whom may have come by the "Drove"—stood firm. There was a terrible slaughter, so much so that King Olaf's saga, the "Heimskringla," says that

"Hringmara Heath
Was a bed of death."

A mile east of Ringmere, the "Drove," after crossing a heath on which Neolithic flint implements of distinctive type occur sporadically, unites with Peddar's Way and terminates its course.

From its likeness to prehistoric trackways in other parts of the country, its connection with Peddar's Way, the abundance of relics of Neolithic man found along its entire length, and the evidence furnished by subsidiary roads and trackways, there seems every reason to believe that the "Drove" is a remarkably well-preserved channel of communication used by prehistoric man.

A SPECIAL catalogue has reached us from the Sanitas Electrical Company relating to that branch of electro-therapeutic apparatus which embraces the various forms of lamps employed for surgical purposes. The catalogue, which to the layman is a revelation of the scope and development of the instruments of diagnosis that have been perfected since the invention of the electric lamp filament, embraces the latest improvements in Cytoscopes Œsophaguscopes, Universal Electroscopes, Opthalmoscopes, Head Lamps, lamps for the examination of the mouth and throat, lamps for direct illumination from the outside, for trans-illumination, and for examination of the internal organs. The universal electroscopes of Professor Caspar, and the Broncho-Œsophaguscope of Dr. Brünings, both of which instruments have lately been associated with novel and difficult operations, will arouse most interest among scientific readers.

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The Yeast Cell and Its Lessons.

By W. STANLEY SMITH.

IT has often struck me that the debt modern science owes to that simple organism we call the yeast cell has, perhaps, never been sufficiently considered by the majority of well-educated mankind. It may be that in the haste and turmoil of industrial life many details of considerable fascination must necessarily escape our ken; it may be, alas! that some of us are content to live our lives amongst phenomena of which, as Sir Oliver Lodge once said, "we care nothing and know less." Be this as it may, I venture to think that an odd half-hour spent in those delightful fields of thought which envelop yeast and its simple cellular life will not prove entirely unpleasurable, nor, indeed, without some measure of intellectual profit.

I do not propose to delve far back into the dusty records of time. It will suffice for our purpose if we place ourselves beside the old Dutchman, Van Leeuwenhoeck, and take a glance through the early microscope of 1680. In the field of vision many globules floating in a fluid will be discerned; and these, forsooth, are yeast cells seen in their naked simplicity for the first time by mortal eye. It was thus found that brewers' barm possessed a definite structure, and the primitive step in a long series of discoveries duly accomplished; but it is curious to reflect that 150 years should then intervene during which nothing of capital importance was added to our knowledge. With the advent of the 19th century, however, each day brought forth its measure of scientific progress. The scene, indeed, became crowded; men flocked hither and thither declaring novel facts and fancies, and a veritable whirlpool of conflicting statement and contending argument ensued. At this distance of time the multitude grows dim; but certain figures stand out, and are conspicuous among their clamorous fellows. We must note at least four remarkable personages—by name, Schwann, de Latour, Berzelius, and Liebig. The labours of de Latour in France and Schwann in Germany were almost simultaneously crowned with eventful discovery. Yeast, they announced with no uncertain voice, is a living, breeding entity, and, moreover, is the cause of the fermentation of sugar. All this happened during the opening year of the Victorian age, and against these strange utterances many a voice was raised. Those of us who have studied the history of progress in the fermentive arts will easily recall some of the wild and fantastic guesses which were then poured forth; but amongst much intellectual dross there rang out the reasoned opinions of Berzelius, the Swede, and Liebig, the giant of his time. Berzelius had, without doubt, as early as 1827, and with greater certainty in 1839, regarded fermentation as dependent upon catalytic force, or, as he called it, *vis occulta*, and Liebig, whose chemico-mechanical theory held ground for some years, is best interpreted by quoting his own words, as they appear in the classic "Chemistry of Agriculture and Physiology." "In the metamorphosis of sugar," says he, "the elements of the yeast, by contact with which its fermentation was effected, take no appreciable part in the transformation of the elements of the sugar; for in the products resulting from the action we find no component part of this substance."

Many other theories echo from out those times—theories, for the most part, utterly vanished from the ken of practical science. Albeit, a strange value, a vague sense of prophecy is discernible in certain of these long-forgotten figments of scientific imagination. For instance, one might legitimately recall Mitscherlich, with his notion of contact, much akin to the action of platinum sponge, or Meissner, with his purely chemical theory, or, yet again, the strange forecast of Colin and Kaemtz, who deem the whole matter wrapped deep in the mysteries of electricity. Suffice it we have chosen enough for our wants, and it will be apparent how, in the whirligig of time, forgotten lore will suffer resurrection. In the history of science instances are, indeed, not wanting in which old theory clothed in the garb of newly-found facts itself lives anew.

The learned Gabriel Schwann was, by inclination, a physiologist, and his work on yeast must be regarded in the light of experimental means to an ambitious end. He sought in the cell the very foundation of life. "I have been unable," says he, "to avoid mentioning fermentation, because it is the most fully and exactly known operation of cells, and represents in the simplest fashion the process which is repeated by every cell of the living body." Let us place these words side by side with those uttered but the other day by the great Verworm. "It is the cell to which the consideration of every bodily function, sooner or later, drives us. In the muscle-cell lies the riddle of the heart beat, or of muscular contraction; in the epithelial-cell, in the white blood cell, lie the problem of the absorption of food; in the gland-cell are the causes of secretion, and the secrets of the mind are slumbering in the ganglion-cell." It thus appears clear that the simple saccharomycete is typical, even as Schwann argued, of all organised life. But it is not a mere question of crude morphology; this, indeed, is but the least subtle of those analogies which the study of a yeast cell will suggest. As we gaze through the eyepiece of some sufficient microscope, or, better still, observe the seething world of the brewers' fermenting vat, we may be tempted to ask the old, old question, Whence and Whither? What lies behind this fierce energy of decomposition, this astounding fecundity, this altogether absorbing mystery of life? These are the problems which men of science have set themselves to solve, and already they have gone far. I think that it would not be difficult to refer the latest opinions of biologists to the direct and logical result of reasoning which was primarily suggested by research on the mechanism of the yeast cell. "Physiology's present answer to the old question," says a recent writer, "is, very simply, life is a series of fermentations." And, if it be urged that we do not yet know what is fermentation, that we know as little of the working of the housewife's barm, or the brewer's malt, as of life itself, there will be no one to gainsay. For, curiously enough, they seem one and the same thing.

There is a plate let in above the doorway of a house at Dôle, in the Rue des Tanneurs, on which is inscribed this simple phrase: *Ici est né Louis Pasteur, le 27 Decembre*, 1822. And, whilst I may unhesitatingly say that few more momentous events have occurred in the annals of science, I am tempted to add that Pasteur's birth was of equal moment to the whole of humanity. For what manner of man was this lowly-born tanner's son? And what was the outcome of his labours? Let Lord Lister tell us in his own grateful words. He said, "Pasteur's researches on fermentation have thrown a powerful beam which has lightened the baleful darkness of surgery, and has transformed the treatment of wounds from a matter of uncertain, and too often disastrous, empiricism into a scientific art of sure beneficence." Pasteur's life has been laid bare to us by several writers, among them his son-in-law Bompas, and, in a clever little monograph, by Mrs. Percy Frankland. From the

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latter work we gather how Pasteur, in his youth, was much addicted to the gentle Waltonian art. Indeed, for some years he took no heed whatever of books or other dry-as-dust learning. It was not until dire necessity forced him that fishing-rod, paint-box, and other profitless joys were forsaken, and our student at the Sorbonne discovered his God-given gifts. And then a certain old woman of Arbois, in her rural wisdom, made this odd remark: "What a pity," said she, "that Louis should bury himself in a muck-heap of chemistry, for in truth he would some day have succeeded in making name and fame as a painter."

It is a legitimate question to ask why Pasteur happened to take up the study of fermentation. The answer affords another of those happy chances which are the salt of scientific life. As a crystallographer he was bent on solving those old problems suggested by the tartaric acids. He noticed how one type of this acid deflects the beam of light to the right, another to the left. Further, he chanced to observe that certain micro-organisms exercise a selective action when sown in these solutions—thriving in one, pining in the other. Here then was a clue, for surely the contents of the cells Schwann had declared alive must control such dainty selective action. What followed in those fruitful years it were quite needless for me to recapitulate. Liebig and his molecular oscillations were forgotten by all save the faithful few, and for 40 years mankind revelled in the thought that the fermentation of sugar was indissolubly connected with the life action of a living organised structure. Yet, on the crucial point, Pasteur was in error. It must not be forgotten, however, that by his classical experiments with the isomeric tartaric acids Pasteur practically laid the foundations of stereo-chemistry. The development of this fruitful branch of learning was, necessarily, slow at first, and, indeed, it was not until 1873 that much headway was achieved. In that year Wislicenus pointed out the deductions of his work on lactic acid, and it seemed clear to men of science that the difference between compounds of identical structure was due to differences in the "arrangement in space" of atoms within the molecule. It is to the further development of this difficult subject, at the hands of Le Bel and van 't Hoff, who elaborated the theory of the asymmetric carbon atom, that we largely owe our knowledge of the carbohydrates.

The new century opened with new ideas. A book dealing with experimental research on alcoholic fermentation, and relating the results of laboratory experiments dating from 1896, appeared in the year 1903. It is entitled *Die Zymasegärung : Untersuchungen über den Inhalt der Hefezellen und die biologische Seite des Gärungsproblems*. The authors' names are Eduard Buchner, Hans Buchner, and Martin Hahn; and it became evident something noteworthy had happened. It was briefly this : Buchner, unhampered by any prejudice concerning the connection of vitality with fermentation, betook him to see what was really inside the yeast cell. Accordingly, he mixed a small quantity of barm with very fine sand, and he then subjected the whole to enormous pressure. This hard quartz crushed the little yeast cells to merest pulp, and therefrom flowed a wonder-working fluid. It was found that Buchner's liquor effected exactly the same fermentation in a saccharine solution as did yeast itself. This research of Buchner's actually proved what was long ago conjectured by Liebig, Traube, Berthelot, and Hoppe-Seyler, namely, that the intra-molecular transformation of sugar into alcohol and carbon dioxide is due to an enzyme secreted within the yeast cell.

This capital demonstration forms a fitting climax to a long series of speculations on collateral fermentations. We will call to mind the main results achieved by toilers in these different fields of research. In the year 1841 two French chemists, Payen and Persoz, succeeded in isolating from germinating barley a substance which seemed to possess an unlimited capacity for saccharifying starch. They called this substance *diastase*. Later on, in 1860, we find Berthelot experimenting with yeast, and he isolated the substance to which Béchamp, in 1864, gave the name *zymase*. Thirty years after Donath changed this name to *invertin*, and we thus clearly have species of chemical substances which, when abstracted from living organisms, are able to effect certain well-defined fermentations. Meanwhile, it has been shown that many processes of higher life appear to be governed by these soluble, unorganised ferments, or, as Kuhne, in 1878, proposed to call them, *enzymes*. Incidentally, I should here mention that, like many other *termini technici* with which we are familiar, these expressions, ferment, diastase, enzyme, or what-not, must be understood historically; just as logic, metaphysic, analytic organon, &c., can only be apprehended and understood historically. In 1831 Leuchs discovered that saliva possessed the property of saccharifying starch, and fourteen years after Miahle isolated the ferment, and called it *salivary diastase*, a name far preferable to that bestowed upon it by Berzelius, but which remains to this day, I mean *ptyalin*. Then followed the discovery that the specific functions of the stomach, liver, and pancreas were each controlled by their specific ferments, which we shall recognise as *pepsin*, *rennet*, and *ptyalin*. And now, as the result of the brilliant young Gabriel Bertrand's work, we are even bid to associate the taking up of oxygen by the lungs with the necessary presence of an enzyme, which he has called, appropriately enough, *oxydase*.

It is now possible to discern the connection of Buchner's bold experiment with all this more purely physiological work. He proved that the phenomena apparent when yeast is added to brewers' wort are identical in principle with all these other fermentive actions, and all the research of more recent years tends but to strengthen one's opinion that the most important functions in the economy of life are under the control of enzymes, or, in other words, partake of the nature of fermentation. Quite recently Dr. Harden has had something to say about zymase. His memoir is illuminating, and, if that were possible, still further opens our eyes to the complexity of the subject. He indicates the presence in yeast juice of "something" of an organic nature which is not affected at boiling temperatures, and to which it owes its power of converting sugar into alcohol and carbon dioxide. Should this nameless "something" be withdrawn from yeast juice, zymase almost loses its characteristic; but, on the other hand, if more be added, so as to swell the normal quantity, the action of zymase may be doubled or quadrupled in ratio to the quantity present. We touch here upon the difficult problems connected with the, so-called, co-ferments, and we are clearly on the fringe of important discoveries. Indeed, many facts are already at hand which only want of space compels us to withhold for the purposes of the present article. Some German chemists, Bredig among others, have been able to imitate very closely certain fermentations by means of finely-divided metals, such as platinum or gold, and these curious ferment-like solutions may be "poisoned," chloroformed, or killed just as if they were alive. This is all extremely odd, and most perversely mechanical; but there is something behind these phenomena which awaits correlation with vinous fermentation. Meanwhile, about three years ago the *Zeitschrift für Physi-*

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calische Chemie published the following remarkable research, which must furnish us with all the evidence we have leisure to adduce on this occasion:—In the course of his paper on the "Influence of Metals on the Hydrolysis of Cane Sugar," R. Vondrácek draws attention to the fact that authorities differ "as to the effect of metals on the well-known slow inversion of saccharose by boiling water," and proves experimentally that strips of platinum foil do not appreciably influence the rate of inversion, thus confirming the results obtained by Lindet. On the other hand saccharose (cane-sugar) is rapidly inverted by boiling water in the presence of platinum black. Sugar solutions acquire a decidedly acid reaction by heating with platinum black for 15 minutes, and the filtrates undergo inversion on further heating. If after inverting a sugar solution by treatment with platinum black for eight hours the powder be immediately heated with a fresh solution, the latter develops no acidity, and it is not inverted more rapidly than by water alone, but the inverting property of the platinum black is restored by exposure to air. Again, platinum black which has been previously deoxidised by treatment with ammonia, has no influence on the rate of inversion by pure water. From these data it is concluded that the inversion by platinum black is due to the oxygen contained in it, which oxidises a part of the saccharose to one or several organic acids, and thus supplies hydrogen ions to the solution.

But fermentation is destructive. The ferment of yeast splits up sugar into alcohol and carbon dioxide; pepsin resolves albuminous foodstuffs into substances of, presumably, simpler molecular composition, and so all through the list we have had occasion to mention. On the other hand, side by side with this incessant destruction, life is characterized by incessant construction. These form, indeed, the two most striking and essential phenomena of the life process; the destruction, the analysis, is death; the construction, the synthesis, is life. And a constructive ferment appears, from our knowledge of enzymes, to be a plain contradiction in terms. However, even this stumbling block has apparently been removed, and it was a young Englishman, Croft-Hill, who first showed us that a constructive ferment is not only thinkable, but that it actually exists. And here again the lesson was furnished by a yeast cell. In the month of June, 1899, a paper was presented by Croft-Hill to the Chemical Society, in which it was shown that the action of the maltase of yeast (which is the enzyme charged with the special function of converting the sugar maltose into the simpler, and more readily fermentable, sugar glucose) on maltose is hindered by the presence of glucose, and is incomplete. The effects are more marked the stronger the solution of maltose. If the maltase be allowed to act on a 40 per cent. solution of glucose, there is an apparently reversed hydrolytic action, resulting in the formation of 15 per cent. of maltose, at which point equilibrium occurs. The same equilibrium point is reached whether we start with a solution of maltose or glucose, so that the action is clearly a reversible one. It has often struck me that the divergent results various chemists have achieved in the study of the decomposition of starch may, perhaps, in some measure be accounted for by the action of constructive enzymes, or rather, one would be safer in saying, by the general tendency, under defined conditions, for reversionary processes to become manifest. It is rather more than twenty years ago since Dr. Wohl noted the phenomena of inversion and reversion in connection with the action of weak acids on certain complicated sugars.

If further evidence be required as to the possibility of what I have named constructive ferments, it may be found in Emmerling's work, which I mention with reserve, on amygdaline. Under the influence of one enzyme, emulsin, this substance is split up into sugar, hydrocyanic acid, and the essence of bitter almonds. But it is said that another ferment, maltase, common to yeast, will join these decomposition products together again to form the original substance.

On one very particular point, that is to say, the molecular construction of these enzymes, ferments, or diastases, the world of science is almost entirely ignorant. This question forms one of the many chemical problems of the hour, and we start with the shallow fact that they contain the simple elements found in charcoal, air, and water. Beyond this we know next to nothing. I think, however, we may console ourselves with the reflection that we are at least on the eve of important discoveries. My friend, and former "chief," Emil Fischer, of Berlin, having vied with Nature herself in the manufacture of sugars, has now turned his attention to proteid substances. The intervening gulf has already been bridged, inasmuch as Fischer has traced the connection between the configuration of a sugar and its behaviour towards ferments. This is the famous "Schloss und Schlussel" theory, the happy analogy of "lock and key." It is our everyday experience that yeast cells assimilate more easily the sugars of which the molecular configuration closely resembles that of the most digestible of all carbohydrates, namely, glucose. Many of the artificially produced sugars, as for example the aldoses, gulose and talose, are quite indifferent to the fermentive efforts of yeast, and the complicated bi- and tri-saccharoses are, for the most part, resolved into simpler molecular constructions before suffering the usual decomposition.

There is a fertile field of inquiry open to investigation as to whether some of the curious by-blows of fermentive action may not lead to further discrimination between constructive and destructive fermentation. We have certainly arrived at a point, in so far as these studies are concerned, which bids us be cheery as to the future, for the modern man of science has far outstripped those learned forebears of his who, to use Sir Edward Elgar's lugubrious simile, were like "blind men in a churchyard at midnight, trying to read epitaphs in a forgotten tongue." Emil Fischer's work alone has inspired that able chemist, Dr. M. O. Forster, in saying, "It is permissible to prophesy that his contemporary researches among purine derivatives and synthetical polypeptides will culminate in dramatic results, as they have the character of a reconnaissance preceding an attack on the proteids, which chemists anticipate will share the fate of the two other principal food materials—fats and sugars." Dr. Gustav Mann, of Oxford, in his erudite work on the Chemistry of the Albuminoids (a work based on Cohnheim's treatise, but which forms a much expanded version of the original) strikes the student on its perusal as predicting the early synthesis of an enzyme. Indeed, the advances chronicled therein are potential to a singular degree; but it is not yet time for the full fruits of those hundred-fold labours, directed primarily to the elucidation of yeast and fermentation, to fall to the husbandman's sickle.

It has only been possible for me to touch upon one or two of the manifold thoughts which suggest themselves when one watches the activity of yeast. I might have mentioned the interest which was aroused by the publication of Dr. de Backer's volume, *Les Ferments Thérapeutiques*, in 1896; wherein it is noted in how curious a manner the yeast cell will swallow up certain bacteria, pathogenic and otherwise, and it is shown how subcutaneous

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injections of yeasts may possibly be used to destroy the germs of many dire diseases. Again, in proof of the medicinal effects these microscopical cells will occasion, I might have quoted the, perhaps hypothetical, story of the Hertfordshire farmer, who went home late one night and drank a pint of yeast in mistake for butter-milk. He arose three hours earlier next morning. Indeed, the thoughts which crowd around these simple cells partake of a character almost universal. To yeast we owe the nation's bread, and the nation's second necessity, beer; and many other needful liquors are ours through the medium of yeast. So wide is the survey, that the disjointed reflections I have ventured to place before you form but a tithe of those our theme might legitimately evoke. But all these must now be passed over, and we will conclude with one modest Faust dream. If Croft-Hill is right, and the action of maltase is reversible; if Emmerling's discovery that one ferment may undo the work of another be a true interpretation of Nature, then might we not expect the same reasoning to apply, under conditions yet unknown, to those ferments which convert living protoplasm into relatively dead fatty, connective cartilage or bone tissue? Metchnikoff has declared this process is the invariable symptom of advancing years, and we may quite legitimately ask in what manner this apparent discovery of constructive ferments will ultimately affect such momentous problems.

A Railway Builder.

IT has been suggested by the most readable of the prophets of Socialism that some time in the present century the leaseholder who builds houses for the landlord will evade some of the inequalities of his rights by constructing houses that will last merely to the end of his lease; and that one of his adopted methods will be the construction of walls by machinery. In the United States where the increasing use of concrete as a building material gives support to Mr. H. G. Wells's idea, a machine of an equally revolutionary kind is now being used for laying railway lines. It is not easy to describe the machine without the aid of diagrams, but in appearance it is something between a magnified reaper and binder and a traction engine. The rails and ties which it is to lay down are stretched over wheels in much the same way that the cogs of a bicycle chain extend between the pedal axle and the axle of the back wheel. The whole arrangement is drawn by an engine which not only propels itself and the railway track material, sleepers, ties, and rails, but furnishes the motive power by which the material is delivered to the permanent way. The gearing is so arranged that the machine and train are moving very slowly—at a speed of about 30 ft. a minute. "The ties are delivered to the machine itself by means of the rails, which act as the conveyors. When the ties reach the machine they are picked up by an endless chain conveyor, and are carried over the truss to a point 68 ft. in advance of the car, where they are deposited on the road-bed and automatically spaced one at a time as the machine moves forward." With the machine is a crew of forty men, including "spikers" and "nippers." If there is a good organisation three or three and a half miles a day can be laid and "quarter spiked." Evidently the track would not resemble that of the L. and N.W.R. or G.W.R., but it would be useful in a new country.

The Tohunga Maori.

By JAMES BUCKLAND.

To those who have heard the stories of the wondrous powers of the *tohunga*, or Maori priest of old, told with a circumstantiality that invites credence, and attested in many instances by reputable European eye-witnesses, there comes a questioning doubt as to whether this old, old race did not possess a knowledge of forces that we have yet to acquire. Certain it is that the priesthood of the Maori race possessed powers which can be explained only by processes into which we are but now acquiring an insight, while others again were of such an extraordinary nature as to be at present wholly inexplicable. Many white men still living have witnessed some of the outward forms of the observances of the Maori priest, but the esoteric meaning attaching to the ceremonies is for ever lost. The reason is not far to seek. The priests were a sacred class, and their knowledge was guarded with extreme care, only to be taught to those of their direct descendants who were worthy and could be trusted. Nevertheless, had any one of the early missionaries secured the confidence of the old *tohunga*. it is believed that vast stores of knowledge would have been disclosed which would have thrown a flood of light on the origin of the Polynesian race, their religion, and their ritual. But it never dawned on these educated white men that the Maori might be possessed of systems of religion and knowledge of a high character. It was their business to counteract and destroy the influence of the *tohunga* as inimical to the tenets of the religion they themselves taught. Under these circumstances, it is obvious that the *tohunga* would not be communicative. When men of our own race appeared who could sympathise with the Maori priesthood, there were none left in the land. It is true there have been *tohungas* among the Maoris in comparatively recent times. But these had become degenerate through their environment, and would not have been worthy to take their place amongst the learned men of yore. They no longer possessed the powers of old, because they had lost belief in themselves, in the same manner that the people had lost faith in them.

Unlike the medicine-man of most primitive races, whose qualification would appear to be some marked physical deformity or hideous countenance, and who covers himself with grotesque personal adornments, the *tohunga* was of noble birth and splendid physique. He was skilled in the tactics of battles, and not only directed the movements of war parties, but more often than not led them to the attack. Instances are known in which an imminent defeat has been turned into victory by the priest striking his staff into the ground and calling on his braves to die or conquer there. He combined with his astrology a considerable amount of astronomy. There are indications, too, that he knew the earth was round, or, at any rate, that it was not flat. This probably became known to him by the lifting of new stars as he piloted his tribe in its peregrinations south from the land of its origin. Among the many important duties he had to perform was that of the historian, and, like the historian of all primitive races whose national records are preserved orally, he was capable of feats of memory that we can only wonder at. He was also the doctor, the seer, and the poet of his tribe. In a word, his functions were endless. From birth to death he was in constant requisition to perform some ceremony connected with the everyday incidents of life of the Maori.

To all the *tohunga's* operations a *karakia*, or incantation, was a necessary adjunct. It represented the demand

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made by the Polynesian order of mind for some ostensible outward sign connecting cause and effect. Some of the *karakias* have been preserved, but so full are they of allusions to things we have no knowledge of that their translations are often, to our ideas, meaningless. The Maoris themselves at the present day are ignorant of their signification. It will be seen from this that these prayers must be of immense age, and that it is probable they were in use before the Polynesians entered the Pacific.

As a rule, the priesthood descended from father to son. It was also the duty of the father to teach the son. On the conclusion of the teaching—which was conducted in the greatest secrecy—there were several ordeals which the pupil had to perform to prove his proficiency. We have been assured by aged Maoris that the pupil, if proficient, did perform these tests, but I refrain from mentioning them here as they cannot be substantiated by conclusive evidence. I may mention, however, that according to the belief of the people these ordeals were accomplished not by any physical effort, but by the mental operation of willing and by repeating a *karakia*, the spoken words acting as the vehicle connecting the will-power with the object. The particular *karakia* used in these ceremonies was called a *hoa*. We have no equivalent for this word in our language, but it means, as near as I can translate, "exertion of will-power for the destruction of some animate or inanimate object, or to affect its state of being." The action of Jesus of Nazareth in withering the fig tree by the wayside would be, to the Polynesian mind, an exact illustration of the word *hoa*. Or, again, the power ascribed to the *tohunga* of being able to *hoa* a fleeing enemy is aptly illustrated by that mystical power which seems to retard motion in a nightmare.

To turn to cases which can be substantiated by a great mass of evidence, I shall take first the power of *makutu*; though there is, I believe, a natural explanation of this dread power. It is a matter of common knowledge that when a Maori believed he was bewitched unto death, he died. The reason, I think, was this. The Maoris of the olden time possessed extraordinary powers of belief. They were a people in whom faith was a reality. *Makutu*, doubtless, was largely the effect of hypnotism and suggestion conveyed by telepathy, and it is well known that these mental sciences are based on faith or belief. Consequently, when a Maori believed that a priest had bewitched him, the suggestion, falling on ground prepared by faith, rapidly effected its object.

Concerning telepathy, instances of direct transference of impressions from one mind to another at a distance are known to have occurred in days not beyond the range of living memory. We have it on the authority of educated white men whose names are household words in New Zealand that the thoughts and feelings of the *tohunga* were endowed with the faculty of locomotion, and travelled by other than the material courses of which we are commonly conscious. A *tohunga* of a high class could, by the exercise of some power of mental interaction, influence persons at a distance—could, for instance, summons from a distance some relative or friend, or bring about a meeting between distant persons, one of whom desired to see the other.

Another power ascribed to the Maori priest of old was that of influencing the dead. The following illustration of this potency—one of many authenticated instances which could be adduced—occurred in the Rotorua district in the presence of several learned Englishmen. A warrior, slain in battle, had been brought home and placed on a bier in order that the relatives might *tangi*, or wail, over the body in due form. As satisfaction for wrongs received, real or imaginary, is the first law of Maori nature, it was natural that the tribe should wish to know if, and when, vengeance should be theirs. The *tohunga* was summoned and requisitioned to obtain some omen from the dead brave which would foreshow the result of the next encounter with the enemy. When all were seated in a ring about the bier, some ten paces from it, the *tohunga* advanced, and coming close to the corpse, but not in contact, commenced to recite a *karakia* with the intent to induce the departed hero to vouchsafe to the tribe the desired information. Nothing disturbed the current of the incantation but the wailing of the relatives of the deceased, whilst every eye was fixed on the bier on which the subject lay. At a certain part of the *karakia* the corpse was observed to *kori*, or move slightly to one side. Whereupon a great cry arose from all present, for the movement was accepted by the tribe as a certain sign of future victory. This manifestation was, of course, due to craft on the part of the *tohunga*. But how? Unless we are to believe that the corpse was stimulated to factitious animation by the priest giving out his own magnetic and electric forces, we must suppose that he had the power of hypnotizing large numbers of people at the same time—a phase of hypnotism with which we are as yet unacquainted. It is conceivable that the belief of the Maoris in the powers of the *tohunga* may have acted in many cases as if those powers were real. But the English eye-witnesses had no belief either in the *tohunga* or in his powers—were, in fact, sceptics, prepared to expose a fraud—yet the Maori, by some mental influence, some form of hypnosis, as I think, was able to make them believe that they had actually seen the corpse move.

I have mentioned that among the numerous functions of the *tohunga* was that of seer. Prophetic vision, known to the Maoris as *mata-kite*, was common among the priests of the olden time. It was analogous in some respects to the Highlander's second-sight, and is a subject full of interest. Authenticated cases of *mata-kite* have occurred in comparatively recent times.

It is also worthy of note that the fire-walking ceremony as performed at the present day by the Fijiians, and of which no explanation is forthcoming, was practised by the Maori priesthood in times gone by.

With the fewest strokes of the pen possible I have outlined some of the powers possessed by the *tohunga* Maori of old. There is much in this peculiar cult that is understandable; there is more of which we are unable to find any natural explanation. But I believe the time is not distant when discoveries, now dawning, will show that operations which the early missionaries looked on as trickery, or as works of the Devil, to be approached only with a view to their extinction, had some foundation in fact and were the relics of a very ancient system of knowledge which the Polynesians brought with them from far-away India, and which probably they acquired from some of the Aryan races.

Industrial Electrical Measuring Instruments, by Kenelm Edgcumbe (London: Constable and Co., 1908; 8s. net).—This is a book written by an engineer for engineers. It is intended to supply a work dealing in a comprehensive manner with electrical measuring instruments, by which phrase is meant those which are used commercially and not merely in laboratory practice. Various types of ammeters and voltmeters, wattmeters, pyrometers, oscillographs, relays, etc., are described in turn, with practical directions as to their use. The volume will serve its purpose quite well. It must, however, be understood that it in no way attempts to give the theory of the instruments described.

The Sea, Carbon Dioxide, and the Duration of Human Life on the Earth.

By J. C. GREGORY, B.Sc., A.I.C.

IT has been calculated that the combustion of coal throws every year into the atmosphere $2{\cdot}4 \times 10^9$ tons of carbon dioxide. If this figure is accepted, it works out to about 76 tons per second. On an average, then, there is an addition of about 76 tons of carbon dioxide to the atmosphere from the burning of coal in every second of time. If these 76 tons of carbon dioxide were all massed together under average atmospheric conditions they would occupy about 8,616,000 gallons. Carbon dioxide being about $1\frac{1}{2}$ times as heavy as air, it might be thought that all the gas thus poured into the air would tend to settle to the bottom of the atmosphere and form a thick layer on the surface of the earth. In the well-known Poison Valley of Java, the accumulation of carbon dioxide tends to suffocate animals that enter it. In the Grotto del Cane, near Naples, dogs are apt to be asphyxiated by the underlying layers of carbonic acid gas. The exceptional character of such places, however, tends to prove that atmospheric carbon dioxide does not form a bottom layer. The gas really spreads itself throughout the atmosphere.

Now, although there is a constant flow of carbon dioxide into the air from organic and inorganic sources, the total amount of this gas in the atmosphere remains remarkably constant. It appears to be increasing slightly, but only very slightly. The total amount of carbon dioxide in the air has been computed to be about 1000 times the quantity produced annually by the burning of coal. Its total weight is therefore about $2{\cdot}4 \times 10^{12}$ tons. The most recent estimate of the total population of the world suggests the figure $1{\cdot}5 \times 10^9$. For every human being in the world, there are, therefore, about 1600 tons of carbon dioxide in the atmosphere. Compared with the amount of carbon dioxide expired by the total population of the world in one year, the total amount of carbon dioxide in the atmosphere is very great. Roughly speaking, 1,000,000 human beings expire about 2·5 tons of carbon dioxide in one hour. This is only an approximate figure, but it is enough to indicate that the respiration of the population of the globe would take a long time to produce the total amount of atmospheric carbon dioxide. According to this figure, the $1{\cdot}5 \times 10^9$ inhabitants of the globe daily expire 90,000 tons of the gas. This would amount to 32,950,000 tons in one year. Approximately 71,000 years would therefore elapse before the total amount of carbon dioxide in the air could be obtained by the breathing of the present population of the globe. In this approximate calculation, no account is taken of the respiration of beasts.

The carbon dioxide produced from all sources and poured into the atmosphere tends to mix uniformly with the other gases of the air. But just as cold water from the North Pole or the warm waters from the Gulf Stream constitute definite currents before they are completely mixed up with the main body of oceanic water, so there tends to be a larger proportion of carbon dioxide in the neighbourhood of the places where it is generated. Thus in the air of the Grotto del Cane there is a relatively large proportion of carbon dioxide. It takes time for the generated gas to diffuse away and scatter uniformly through the atmosphere. In the same way the proportion of carbon dioxide is greater in the neighbourhood of cities and towns than it is in unpopulated districts.

This is more particularly the case in the rooms and houses of towns and cities. When the carbon dioxide breathed out by their inhabitants is more or less shut in by doors and windows, it naturally takes longer for the gas to diffuse away. One object of ventilation is to hasten the mixing of the expired carbon dioxide with the main body of the atmosphere. To a person entering from the open air, a room begins to "feel close" when in every 10,000 cubic feet of air there are six feet of carbon dioxide. Under these circumstances the amount of carbon dioxide contained in a room 50 feet long, 10 feet high, and 20 feet broad would be about equal in volume to a ball $11\frac{4}{5}$ inches in diameter. It is usual to take this as the maximum amount of carbon dioxide allowable. This proportion of the gas is perhaps not dangerous in itself, but it acts as an index of the pollution of the air. It is the volatile organic matters expired along with the carbon dioxide that make the room unhealthy. Most people suffer from headache and depression in an atmosphere containing 15 cubic feet of carbon dioxide in every 10,000 cubic feet of air. Too great a proportion of carbon dioxide is, of course, in itself inimical to health; and a great excess will produce suffocation. But the usual effects of vitiated atmospheres are mainly due to other products of decomposition. The smell of such vitiated air is due to these "volatile ptomaines."

It is an interesting fact that the proportion of atmospheric carbon dioxide is usually greater on mountain tops than lower down. At the top of Mont Blanc the carbon dioxide is present in more than one and three-quarter times its average proportion. Ordinary air contains, on an average, rather more than three and one-quarter pints of carbon dioxide in every ten thousand pints of air. In every ten thousand pints of air at the summit of Mont Blanc there are about six pints of carbon dioxide. The proportion of carbon dioxide at the top of Mont Blanc just about reaches the limit below which it is considered desirable to keep the carbon dioxide in rooms. In the case of the mountain air, however, the carbon dioxide does not indicate respiratory pollution, and is probably connected with the comparative or total absence of vegetation. Carbon dioxide is a food of green plants, and where there is much vegetation it is accordingly drawn off from the air. By means of the green colouring matter (called chlorophyll), and assisted by the sunlight, plants remove the carbon from the carbon dioxide and breathe out the oxygen again. Since sunlight is necessary to enable plants to do this, the proportion of carbon dioxide in the air usually rises at night. Foggy weather often produces a slight increase, which may be partly due to the cutting off of the sunlight.

The constant withdrawal of carbon dioxide from the air by plants helps to balance its emission into the air from all the various sources. Although the amount of carbon dioxide in the air appears to be slightly increasing, there is a striking constancy in its total amount. It seems very remarkable that the influx and efflux of the gas into and from the air should so well balance one another. It has recently been pointed out that the sea acts as a regulator of the amount of atmospheric carbon dioxide. It does this by dissolving a proportion of the excess of the gas over the normal amount; and, under certain circumstances, restoring some to make good any deficiency.

In view of the relatively great disturbance of the balance between the carbon dioxide emitted into and withdrawn from the atmosphere by the burning of coal, this regulative effect becomes an important factor in the economy of Nature. Many investigators think that a doubling of the proportion of carbon dioxide normally

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present in the atmosphere would almost render the air unfit for continued respiration. As already seen, about 71,000 years would elapse before the respiration of the present population of the globe would convert the approximately 3 volumes of carbon dioxide per 10,000 of air into twice that amount. Since the carbon dioxide produced annually by the combustion of coal appears to be about ·001 of the total volume in the atmosphere, 1000 years of coal consumption at the present rate would produce the same doubling. Assuming that the action of vegetation, &c., fairly well balances the effects of respiration, decay, and other processes that pour carbon dioxide into the air, the relatively great production of the gas by the combustion of coal might become a serious matter.

To understand the regulative action of the sea imagine a cubical vessel having a capacity of 20,000 cubic feet. If this vessel is half-full of pure water and half-full of air it will contain 10,000 cubic feet of each. Suppose that the vessel is completely closed in, and that the air contains three cubic feet of carbon dioxide. That is, if all the carbon dioxide spread through the air were collected together it would occupy three cubic feet. This amount represents, approximately, the average amount of carbon dioxide in the air. The air, including the carbon dioxide, will proceed to dissolve in the water. The dissolved air will gradually spread through the water until the water has dissolved as much as it can take up. Two processes are really concerned. In the first place air dissolves in the water—passing from the space above into the water. At the same time, some of the dissolved air escapes from the water into the upper space. As long as more air passes from the space above to the water than from the water to the space above, the water continues to extract air from the upper space. It is evident that as long as the dissolved air continues to increase in amount, the amount of air escaping from the water in a given time will continue to increase, because there is more air to escape. In course of time the two processes balance one another—the exports ultimately equal the imports—and the water now contains as much air as it can take up (under the circumstances). When this equilibrium is attained, the pressures exerted by the dissolved and atmospheric air are equal to one another.

Now consider the carbon dioxide alone—ignoring the other gases. As a matter of fact, the carbon dioxide behaves just as if it alone occupied the whole space. When the water has taken up—dissolved—as much carbon dioxide as it can, about one and a-half cubic feet of the gas is dissolved in the water and the remaining one and a-half feet remains in the air above. If there had been six cubic feet of carbon dioxide to begin with, three of these would have dissolved in the water. The water and the air above contain about half each of the carbon dioxide. This is when the volumes of the water and air are equal. If the volume of the water were twice that of the air, it would dissolve about two-thirds of the carbon dioxide; and the remaining third remain in the air, and so on. If now a little more carbon dioxide is introduced into the air above, some more dissolves in the water until it is again equally divided between the equal volumes of water and air. If a little carbon dioxide is removed from the air above, some carbon dioxide escapes from the water until the remaining gas is again equally divided between the water and the air. Thus the water tends to keep the amount of carbon dioxide in the air above constant, dissolving more when the amount increases and giving up some when the quantity decreases. It cannot, of course, keep it perfectly constant, but if there is a very large quantity of water it can do much in this direction.

The very large total volume of the sea has a very considerable effect in maintaining the constancy of the proportion of carbon dioxide in the air. It has been calculated that the sea contains about twenty-seven times as much carbon dioxide as the atmosphere. The amount of carbon dioxide absorbed by the sea is affected by the salts dissolved in it, so that the preceding paragraphs do not give a complete account of the matter. The water of the North Atlantic has been shown to contain 49 c.c. of carbon dioxide per litre. This is equivalent to 490 parts per 10,000. This carbon dioxide contained in sea-water may be for practical purposes divided into two parts—one being regarded as existing in combination as carbonates or bicarbonates and the other being free to diffuse through and out of the water just as in the case of carbon dioxide dissolved in pure water. These two portions are not absolutely unconnected—it is well known that bicarbonates like those of sodium and calcium tend to decompose in solution, and that excess of carbon dioxide converts some carbonate into bicarbonate, but sea-water always contains some free carbon dioxide.

Equilibrium between this free and the atmospheric carbon dioxide is attained when the pressures of the two are equalised. As just seen, in the case of pure water the pressure of the dissolved carbon dioxide becomes equal to the pressure of the atmospheric carbon dioxide when the volume of the dissolved gas per litre of solution is practically equal to its volume in a litre of air. A constant interchange thus takes place between the surface of the sea (and of other waters) and the air above it, according as the pressure of the carbon dioxide is greater in the air or in the water. Any deviation from the normal proportion of carbon dioxide in the air produces a compensating effect by altering the pressure of the atmospheric portion of the gas which results in absorption by the sea of some of the excess, or in the introduction of some of the dissolved gas into the air to make good the deficiency. Investigation appears to indicate that the pressure of carbon dioxide is less over the surface of the sea than over the land. If this is so, the accumulation of carbon dioxide in the air may be regarded as being continuously retarded by the constant absorption by the sea of any excess over the normal quantity. Since the presence of any considerable excess of carbon dioxide over its present amount might seriously interfere with animal life, it is evident that the sea may play a very important part in determining the length of the period for which the earth can continue to be habitable by man.

Outlines of Physical Chemistry, by G. Senter, Ph.D., B.Sc. (London: Methuen and Co.; pp. xvii. and 369; 3s. 6d.).—Notwithstanding the number of works on physical chemistry that have recently been published, the present book fully justifies its appearance. Its aim is to serve as an introduction to the more purely physical side of chemistry, and, therefore, while the relationship between physical properties and chemical composition is dealt with less fully than usual, special attention is given to the more difficult parts of the subject, such as the theories of solution, electrical conductivity, and electro-motive force. In fact, as the author points out, the subject of electro-chemistry is so fully treated that the book may be used as an elementary text-book by electrical engineers. The experiments described are, for the most part, such as require only the most simple apparatus, but references are given to books dealing with more complicated apparatus. Ample references are also given to original papers on the theory of the subject, but it would be an improvement if a bibliography were appended to each section. The hand of the expert teacher is manifest on every page, and we can thoroughly recommend the book as a clear and efficient guide to the physics of chemistry.

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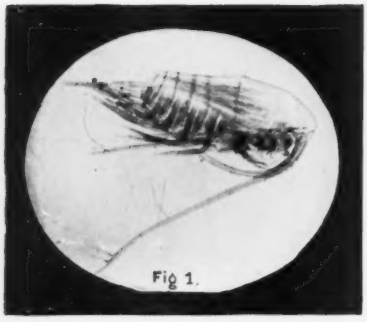
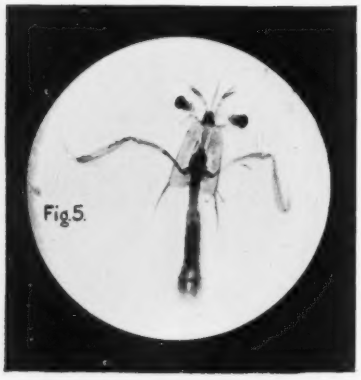
Studies in Marine Life.



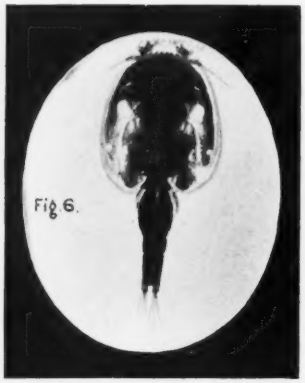
A Copepod (*Calanus finmarchicus*). (*Microphotograph.*)

A Zoea. (*Microphotograph.*)

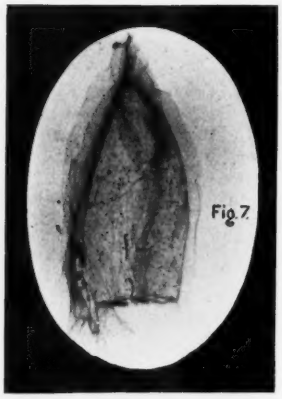
A Copepod (*Centropages typicus*). (*Microphotograph.*)



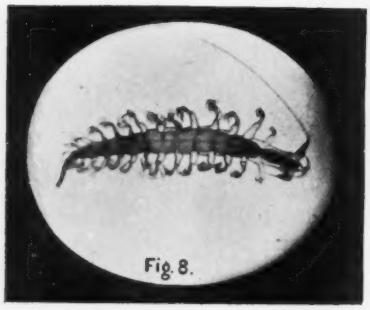
Larva of *Squilla desmarestii*. (*Microphotograph.*)



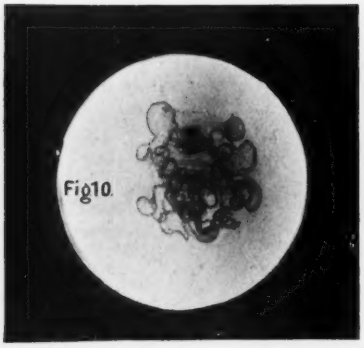
Fish Louse (*Caligus rapax*). (*Microphotograph.*)



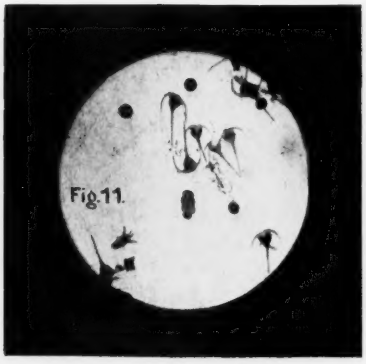
A Siphonophore (*Muggiwa atlantica*). (*Microphotograph.*)



Annelid (*Tomopteris helgolandica*). (*Microphotograph.*)



Echinoderm Larva (*Auricularia*). (*Microphotograph.*)



Flagellate Infusoria (*Ceratium tripos*). (*Microphotograph.*)

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Studies in Marine Life.

III.—Zooplankton.

By G. E. BULLEN.

THE word "plankton," of comparatively recent introduction into scientific parlance, is derived from the Greek verb signifying "to wander." The terms "Zooplankton" and "Phytoplankton" are necessary enlargements denoting whether the heterogeneous assembly of micro-organisms, so called, belong to the animal or vegetable kingdoms. Briefly defined, therefore, the word, when used in a collective sense, may be applied to all aquatic vegetable and animal organisms, which are not sedentary in habit, but freely locomotive. In a restricted and generally accepted sense, however, "Zooplankton" includes a large number of minute forms of animal life, which may be collected by means of the ordinary muslin "tow-nets," forming part of the marine biologist's equipment.

Insignificant as these micro-organisms may appear when viewed separately, collectively they constitute an important factor in the causes governing the extent of inshore migration of herring, mackerel, and other surface-feeding fish. For during the spawning season, when drift fishes are shoaling at the surface, plankton forms the exclusive diet. The abundance or paucity of this food in the inshore waters during the West of England mackerel fishery has been shown to correlate largely with the quantity of fish landed, and these conditions will in all probability be found to obtain in the case of drift fisheries elsewhere.

Fig. 3.—"Phyllosoma" stage of Lobster.
(From a microphotograph.)

The varied nature of well-assorted plankton may be apparent when we find examples of *Peridiniales*, *Diatomaceæ*, and other allied *Protophyta*, together with *Protozoa*, *Cœlenterata*, *Crustacea*, and other *Invertebrata*, either in developmental or adult stages, with fish *ova* and *larvæ*, in a single sample!

In the English Channel, however, whence most of the specimens to be described were obtained, the general rule appears to exist that Phytoplankton generally is more abundant in winter than Zooplankton, this condition being entirely reversed during the late spring and summer months. The reason for this seasonal change has not as yet been perfectly elucidated, but it has been suggested that diatoms and other protophyta, organisms which flourish in fresh water throughout the summer, form food for the larger zooplankton in the sea, their numbers being thus substantially diminished. The exact nature of the food of copepods and other crustaceans, forming the bulk of zooplankton, has yet to be determined, and the diminution of phytoplankton may be attributable to a variety of other causes.

It is now a recognized fact, that certain, if not all, of the more abundant zooplankton organisms, especially crustaceans, move about in shoals of greater or less extent. In certain years, when the western mackerel fishery has been very profitable, the sea has been observed literally teeming with minute animal life. This has been found to be due almost entirely to the presence of vast numbers of two or three species of copepods, forming, by reason of their oily nature, very fattening food for the fish. In the illustrations (figs. 1 and 2) are shown two of these abundant species, viz.: *Calanus finmarchicus* and *Centropages typicus*.

These, and other allied species, exhibit in life a variety of exquisite colours, coral pink, blue, and brilliant green; whilst their elegant form and yet somewhat complex structure and life history render them subjects of much interest to the marine biologist.

Fig. 9.—An Ascidian (*Oikopleura dioica*).

Besides adult forms of crustacea, various developmental stages occur plentifully in samples taken during the early part of the year.

The "Phyllosoma" stage of the common lobster (fig. 3) is interesting, not only on account of its striking appearance, but also for the fact that it is of such uncommon occurrence, despite the comparative abundance of the adult. On the other hand, "Zoea" stages of various crabs (fig. 4) are often plentiful in samples, and occasionally one may meet with the larval stage of one or other of the rarer macrurid crustaceans, such as that of *Squilla desmarestii* (fig. 5).

An interesting copepod, moreover, not strictly speaking a plankton species, but of occasional occurrence in samples, is the Fish Louse, *Caligus rapax* (fig. 6), which is parasitic on various kinds of fishes, and undergoes a somewhat remarkable metamorphosis.

The luminosity of the sea is not entirely due to the presence of *Hydro-medusæ*, though shoals of minute jelly-fishes are largely responsible for the sudden flashes, which

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occur on dark nights, when a shoal of drift fishes, in passing, make a rapid disturbance. Plankton nets are often found to be choked with certain of the larger species after a five-minute haul, and during the summer months several species are often to be met with, together with their near allies, the Ctenophore *Pleurobrachia pileus* and less commonly the Siphonophore *Muggiæa atlantica* (fig. 7). This latter is an interesting species on account of its life history, exhibiting as it does an instance of alternation of generation.

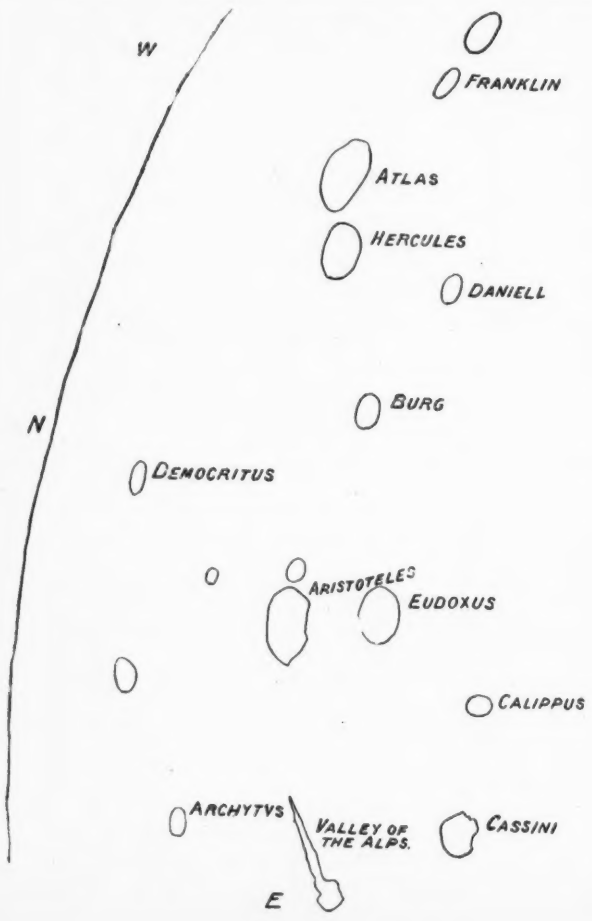
Beside the Arrow Worm, *Sagitta bipunctata*, which often occurs in large numbers in samples, and which, it may be mentioned, is now separated from the Vermes as a class, various developmental forms of Polychaetes and less frequently the interesting species *Tomopteris helgolandica* (fig. 8) are to be observed. The upright position assumed by this latter in swimming, renders it a conspicuous object amongst other plankton.

Oikopleura dioica (fig. 9) is of frequent occurrence in samples; it is an ascidian belonging to the order *Larvacea* and lives at the surface, swimming by means of its tail-like appendage, in which respect it resembles the tadpole larvæ of other ascidians. It is an interesting creature on account of its capability of forming a temporary "house" or test, within which it lives, the limited circulation of water passing through the interior enabling the animal the better to secure its food. The organism itself can leave the house, and secrete another in a few hours.

The free swimming larvæ of Echinoderms are frequently to be met with in inshore waters in large numbers, this being due most probably to the abundant local distribution of the parent stock. The striking metamorphosis, through which the young pass, before assuming the character of the adult, is a subject of much interest; a portion only of the body of the larva (fig. 10) is converted into the substance of the adult form; the rest either being absorbed by the growing animal, or shrivelling up. Various names have been given to these larval forms, *Echinopluteus*, *Ophiopluteus*, *Bipinnaria*, *Auricularia*, &c., according to the stage of development, and the species to which they may be referred. The specimen figured in the microphotograph is *Auricularia*, referable probably to one of the Holothurians or "Sea Cucumbers."

The last forms of Zooplankton, which we shall notice, form as it were a connecting link between the animal and vegetable kingdoms; as animals, they are classed as Flagellate Infusorians, as plants, they constitute a group of the Protophyta called *Peridimales*. Many of the members of this order exhibit striking forms, and occur often in large numbers in samples.

The species figured, *Ceratium tripos* (fig. 11), is perhaps most commonly met with. In common with many other nearly allied forms, it has a cuticular shell of cellulose, which contains chlorophyle, and it is capable of rapid progression by means of the flagellum, lying within the transverse groove. Reproduction is performed by simple fission across the shell; and as with many other Protozoans, Ceratium is highly phosphorescent.



Photograph of the Moon.

THE region represented is the N. and N.W. portions of our satellite, and it includes a number of interesting formations; indeed, every part of the surface may be said to abound in attractive features.

The great *Valley of the Alps* is an extensive cleft running through a lofty mountain range. Small telescopes show it well and its striking aspect makes it a favourite object with astronomical amateurs. It is more than 80 miles long and its average width about $4\frac{1}{2}$ miles, while it is more than 2 miles in depth.

The elevated chain of heights (*Alps*) through which the valley breaks contains some fine peaks, one of them rising to 12,000 feet according to Mädler.

To the south of the Valley is Cassini, a singular ringed-plain enclosing a small deep crater and a pretty level interior not sinking much below the outlying surface. Westwards will be seen a fine pair of craters *Eudoxus* and *Aristoteles*. The latter is the one lying N. and nearer the limb; it is 50 miles in diameter, though not quite so deep as *Eudoxus*, which lies about 11,000 feet below the terraced wall surrounding it.

Much further west and running E. to W. are the craters *Burg* and the large contiguous pair *Hercules* and *Atlas*. *Burg* is deep and contains a lofty central hill. *Hercules* is 46 miles broad and has a pretty conspicuous crater let within it, while *Atlas* is 55 miles in diameter and its ring is very rich in terraces and peaks, some of them on N. side rising to 11,000 feet.

These and other formations constitute a varied and inviting panorama for the student, who will have little difficulty in identifying them and learning what is known of the individual objects from Neison's and Webb's works.

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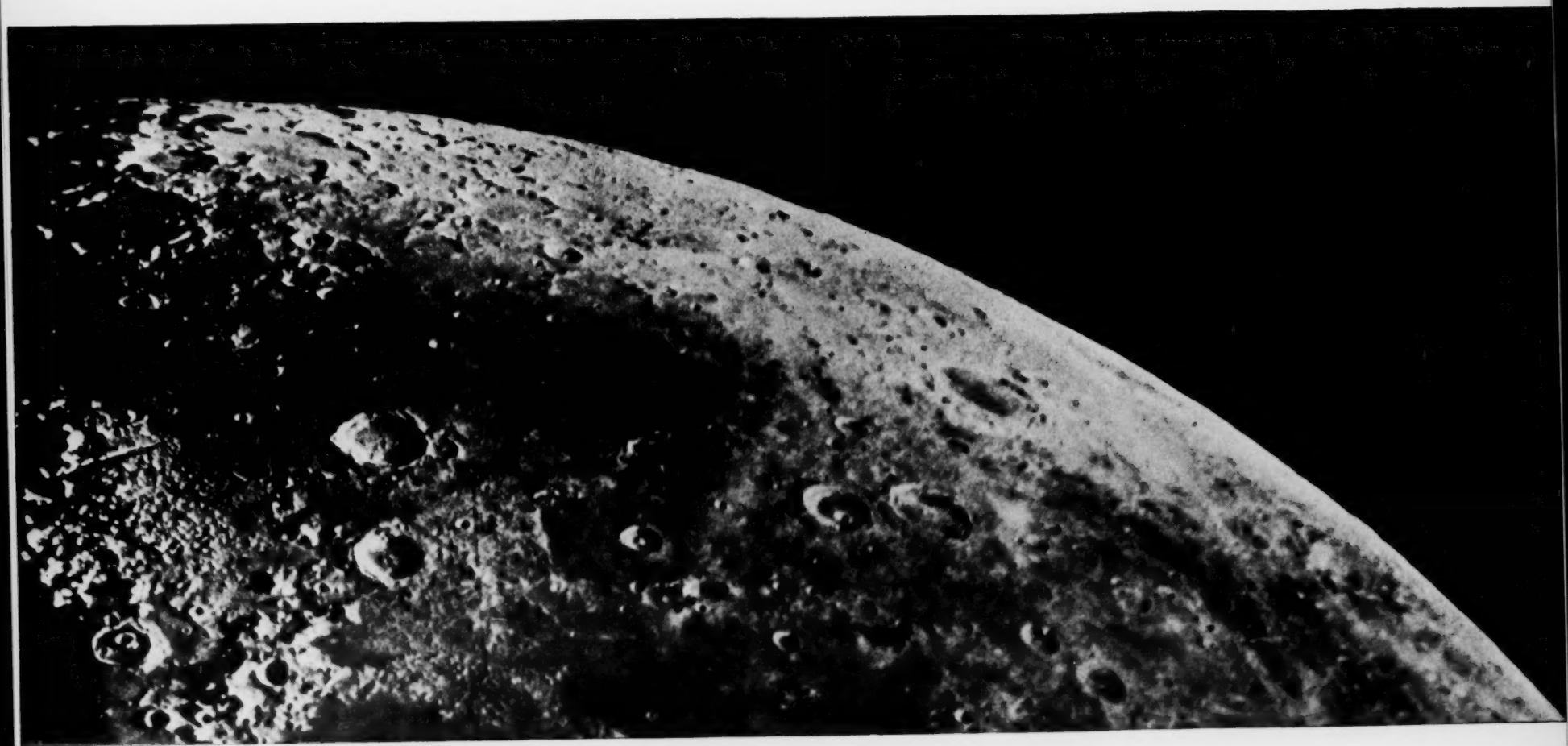

Reproduced by kind permission of the Directors of the Paris Observatory.

The Moon.

Nightingale Land.

By G. W. BULMAN, M.A., B.Sc.

IT is chiefly, perhaps, those who have lived in different parts of England, and so have come to know districts where the nightingale is never heard, as well as those where it is a common summer visitor, who realise most clearly how curiously restricted is its range in this country. And this limited distribution of our choicest songster remains one of the minor puzzles in the great mystery of bird migration. In many parts of England it is never heard at all, and it is unknown in either Scotland or Ireland. In Wales, with one or two trifling exceptions, it is never heard. Nor can the delightful climate of Cornwall tempt it westwards. Northwards it extends only a few miles beyond York. Yet it is heard at Copenhagen in about the latitude of Edinburgh. Professor Newton states that this is the extreme northern point reached by the nightingale, but according to Yarrell it reaches Sweden. Yet even the extreme South of Italy will not serve it for winter quarters, and those which breed there go further south in September.

If we draw on a map of England a line from the mouth of the Tees, by Nottingham and Cheltenham, to the mouth of the Exe, we have roughly defined the range of the nightingale. On the right we have the region where it is heard, and on the left the land where it is unknown. And there is no generally accepted explanation of this restricted range of the nightingale, which seems to be shared more or less by the reed warbler and the wryneck. Now if we draw on a geological map a similar line we notice an interesting coincidence between geological structure and the nightingale's range. For this line cuts off on the right an area consisting of *younger* rocks, from the Trias to the Tertiary, and on the left the *older* strata, from the Permian to the Cambrian. So it has been suggested that the distribution of the nightingale is determined by the nature of the rocks. Cases in which the range of a bird is thus restricted by geological structure are not unknown. Professor Newton mentions the stone curlew as one of the few whose range is so determined in this country. This bird, otherwise known as the Norfolk plover, is practically confined to the Chalk. If the above explanation is accepted for the nightingale, it must be thought to be through the influence of the rocks on its food supply. Thus the nature of the strata determines the prevailing vegetation, and this in turn affects the insect life, in other words, the nightingale's food supply. The bird remains where it can get its favourite insects. It may be suggested that the vegetation on the east of our line supports a different set of insects to that on the west, and that the former suit the fastidious nightingale better. Such, briefly, is the geological explanation. And the theory receives some support from its distribution in France. For it is unknown in Brittany, which is geologically similar to Cornwall, and it does not occur in the Channel Islands. Cowbridge, in Wales, where the nightingale occurs, is on a patch of younger rocks—Liassic—which forms the south of Glamorganshire. This tends, again, to confirm the geological theory, but its occurrence at Tintern, the other Welsh locality, is on Old Red Sandstone, which is a difficulty.

During the present season the nightingale is reported as occurring at Audlem in Cheshire. Now this is some 50 or 60 miles west of the line we have noted as cutting off "nightingale land" on the east, and so the fact seems out of harmony with the suggested geological explanation. A more careful examination, however, shows that it rather supports it. For a glance at a geological map shows that the geological line is here broken, and that the New Red Sandstone rocks of Yorkshire and Nottingham spread out west through Stafford into Cheshire. And close to Audlem itself is an outlying patch of Liassic rocks, on which it may be the nightingale has taken up its abode.

We have not sufficient details of the nightingale's distribution in the other countries of Europe to test the geological theory completely. But the brief notes given by Professor Newton in his article "Birds" in the Encyclopædia Britannica are not inconsistent with it. If, for example, he is right in saying that Copenhagen is its northern limit, the boundary has the appearance of being a geological line. For the island of Zealand, on which Copenhagen is situated, is of Cretaceous rocks like part of "nightingale land" in England. Scandinavia, on the other hand, consists almost entirely of Palæozoic strata, Silurian and still older rocks. If it should turn out that the nightingale, when it occurs in Sweden, is confined to the extreme south, the coincidence would be still more marked. For Sweden's two solitary areas of Cretaceous rocks occur just opposite Copenhagen. The abundance of the nightingale in Mecklenburg is also consistent with the geological theory, for the strata here are of very recent geological age, being in fact post-tertiary. It ought, however, to extend to Danzig, which Professor Newton says it does not. Again, Austria, Hungary, and Galicia, where it is said to occur, possess large areas of Cretaceous, Tertiary, and post-tertiary strata. Finally, as regards Russia, Professor Newton says:—

"It does not reach the Governments near the Ural, though it is said to be plentiful in that of Kharkov, and it is known to visit the Crimea."

And a glance at the geological map of Russia shows that its oldest rocks lie on the western flanks of the Ural Mountains. Kharkov, on the other hand, is Cretaceous, while the strata of the Crimea are Tertiary with some Cretaceous and Jurassic in the south.

Thus we see that, though there are a number of striking facts which seems to indicate that the range of the nightingale is determined by geological influence, we have not sufficient details to make the theory complete.

Professor Newton, summing up the matter, says: "No reasonable mode of accounting for the partial distribution of the nightingale has hitherto been propounded." He adds, however, in a note:—

"When the history of the earth shall be really well and minutely understood, it seems quite possible that as much light will be shed on this and other particular cases of the same kind by a knowledge of the various changes and displacements which sea and land have undergone as has already been done by the same means in regard to many of the general facts of distribution."

This is a geological explanation of a somewhat different nature to the one suggested above.

Endeavours have been made to induce the nightingale to extend its range in this country. Many years ago Sir John Sinclair tried to add it to the birds of Scotland. He obtained a number of eggs from the South of England, and had them placed in robins' nests on his estate. These were duly hatched and reared. They left at the usual time in the autumn, but did not return the following spring as expected. Another attempt was made to establish the nightingale in Wales. A gentleman residing in the district west of Swansea procured a number of young birds from Norfolk and Suffolk. He thought they would return to the beautiful woods and mild climate of South Wales. But they, too, went in the autumn and never came back.

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Photography: Pure and Applied.

By CHAPMAN JONES, F.I.C., F.C.S., &c.

The Flatness of Plates.

No photographic plates are flat, and even if plate glass were used instead of sheet glass this statement would remain true. The same may be said of focussing screens, and it may be added that a large proportion of these might be much better at a quite trivial cost. For work that demands especial care that the sharpest possible image shall be obtained, as, for example, sometimes in photomicrography, in the making of small scales from larger ones by reduction, and in lens testing, it is often worth while to make one's own focussing screens by grinding together two pieces of patent plate glass of suitable thickness until they are both uniformly greyed. For this purpose flour of emery should be elutriated and only the finer part employed. A very small proportion that is the last to settle on elutriation may be found to have no cutting power; this should be rejected. The emery is wetted with water for the grinding and care taken to apply an even pressure with no rocking movement.

The want of flatness in both plates and focussing screens leads to a possible double error in any attempt at critical focussing which becomes very perceptible when using lenses with large apertures. As a proof of the fine definition possible on a Daguerreotype plate an example used to be quoted of a portrait in which there was on a man's coat a fly that could be seen well with a magnifying glass. This was evidence of something more than the defining power of the lens and the capability of the plate to render fine detail, it was proof that the photographer had *happened* to get the image at that part exactly focussed. When it is wished to take extra care in focussing, a loose screen is sometimes used, placing it in exactly the position that the sensitive plate will occupy. Obviously this eliminates any effect due to a constructional fault in the camera, but it has no effect on discrepancies due to the want of flatness of the plate and the screen.

When fine definition is wanted, it is necessary to bear in mind this difficulty of focussing. If the object itself is small and several are available, then a series may be arranged at slightly differing distances from the lens, and the middle one focussed. The sharpest image obtained on development will probably not be the middle one, and a careful comparison of the sharpnesses of the different images will almost certainly indicate whether any of them is the best possible. If only one object is available, then several photographs should be made, and the best of them compared with the best work that the lens is known to be able to do.

Both exposure and development are factors in this matter, for the light that impinges upon the plate is reflected somewhat from particle to particle of silver bromide and so spreads laterally to a certain extent. This spreading increases as the exposure is lengthened, and prolonged development will tend to render it more conspicuous.

Re-reversal.

Every photographer knows that an increase of light action on a plate gives an increase of blackness or density in the deposit produced on development, that as the light action continues to increase there comes a stage at which the increase of density slackens and eventually stops, and that a still further light action causes a decrease in density, commonly called reversal. The effect of light up to this stage is a matter of common observation, for in cases of accidental over-exposure reversal is not infrequently the unwelcome result. Janssen in 1880 found that it was possible to go a stage further, and that by continuing the action of light, after the normal maximum density and the subsequent reduction of density, the density came to a minimum, and then increased a second time. This second increase—that is, the recurrent character of the change—has been doubted by many because of their failure to get it.

In this journal for February, 1906, some experiments by M. Adrien Guébhard are referred to, in which he was able to confirm Janssen's observation, and recently M. A. Gargam de Moncetz (Comptes Rendus, 1909, p. 406) has not only added his confirmation, but also found the reason for the many failures that have been recorded. He used Lumière's Sigma plates, solarized, or over exposed them by subjecting them for a few minutes to the light from an incandescent gas burner, and then allowed a spectrum to fall upon them. Either a Nernst lamp or the sun was used to give the spectrum. The plates were developed with a hydroquinone-metol developer. Whether the spectrum fell on the plate for five minutes or four hours, a blackening was always produced in the extreme red and the infra-red (700 to 1000 $\mu\mu$). A similar result was observed in the ultra-violet, though here the conditions necessary for success were found to be more restricted. But the increase in density in the infra-red is completely lost by a very short exposure to the ordinary actinic rays, so that when white light is employed it is easy to see that the effect of the infra-red and ultra-violet might be neutralized, or partly neutralized, and the result become uncertain. There would remain only the resultant effect of these different actions, and this might be in the one or the other direction, according to circumstances. It is interesting to note that there is an interval of approximately one octave, using the language of music, between the two parts of the spectrum that M. Gargam de Moncetz has found to have this action, and we may well wonder whether light of the next octave above or below would produce a similar effect.

Amidol as Developer.

Messrs. Lumière and Seyewetz have investigated the various suggested methods of adjusting the amidol developer to various exposures. They find that the rapid appearance of the image is a distinct drawback to the use of the time that elapses between the application of the developer and the appearance of the image as an indication of the exposure effect. They find that excessive contrast due to under exposure may be obviated to a certain extent by adding to the normal developer up to as much as three times its volume of a 5 per cent. solution of anhydrous sodium sulphite. A lesser effect, but without the slight tendency to fog that this method shows, is obtained by diluting the developer with three or four times its bulk of water, or by adding to it a strong solution of sodium sulphite. Over exposure within comparatively narrow limits may be compensated for by adding to the developer potassium bromide, sodium bisulphite, or more amidol. The first gives the best results, but if more than five grams per litre (say, two and a half grains per ounce) is added the time of development is considerably increased without any further gain in contrast.

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The Nebula H.V. 30 Orionis.

Reproduced from: "Photographs of Nebulæ and Clusters made with the Crossley Reflector by James Edward Keeler," the Memorial Album published as a tribute to Professor Keeler's memory by the Lick Observatory.

XUM

A New Cosmogony.

On the Cause of the Remarkable Circularity of the Orbits of the Planets and Satellites.

(*Reprinted from Abdruck aus den Astr. Nachr. Nr.* 4308.)
(*Bd.* 180.—*Februar* 1909.)

By DR. T. J. J. SEE.

THE remarkable circularity of the orbits of the planets of the solar system has been remarked from the earliest ages of science. This characteristic property among the orbits of the five major planets known to the ancients was the principal circumstance leading to the development of the Ptolemaic System of Astronomy, which continued in use till the time of Copernicus. It was this singular circularity also that so greatly increased the labours of Kepler in discovering and proving the elliptical law of the planetary motions. In the case of the planet Mars, however, an orbit was at length found which was sufficiently eccentric to enable him to demonstrate from the observations of Tycho Brahe that the path was a true ellipse, and not an eccentrically placed circle, as had been supposed since the time of Hipparchus.

The four large satellites of Jupiter discovered by Galilei in 1610 were soon found to exhibit in their orbital motions about that planet the same extreme circularity that was already familiar in the case of the orbits of the major planets about the Sun; and the tendency to perfect roundness in the paths of the satellites has so often been confirmed by other discoveries made during the past three centuries that this property has naturally attracted the attention of all philosophic observers. The planet Uranus, added to our system by Herschel in 1781, along with Neptune, discovered from the theoretical researches of Adams and Leverrier in 1846, both preserve the same remarkable circularity of orbit which originally called forth the admiration of the Greek geometers; and the orbits of the satellites of these remote planets have likewise proved to be perfectly circular so far as can be judged from the finest observations made with the largest modern telescopes.

The fact of this wonderful roundness of the orbits of the principal planets and satellites excited the speculative curiosity of Kepler and Newton, but at that early date the cause of this remarkable phenomenon necessarily remained very obscure. In due time it was noticed also with equal surprise by Clairaut, Euler, and Lagrange, but these great geometers have left us no record of their conclusions as to how the property arose. Together with the slight inclination and common direction of motion, the small eccentricity of the orbits was one of the principal points of departure in the celebrated researches of Lagrange, Laplace, and Poisson, on the stability of the solar system, with which the famous mathematicians of the 18th century were so greatly occupied.

Though all these illustrious geometers followed the Greeks in admiring Nature's apparent preference for the circle, no one of them attempted to explain the remarkable roundness of the planetary paths till Laplace promulgated his celebrated Nebular Hypothesis (*cf.* Exposition du Système du Monde, Note VII. et dernière, Paris, 1796), and accounted for this circularity of the orbits by a rotation of the central masses which had detached the attendant bodies quite gently and set them revolving in paths of correspondingly small eccentricity.

This explanation of Laplace naturally carried with it the great prestige of the illustrious author of the Mécanique Céleste, and has now been very generally accepted by astronomers for more than a century. And yet it may easily be proved to be untenable and altogether devoid of foundation. It fact it will be shown below that the roundness of the orbits of the planets and satellites is to be ascribed to the secular action of the nebular resisting medium formerly pervading our solar system; and that these bodies have never been detached from the much larger central masses which now govern their motions, by acceleration of rotation, as was supposed by Laplace; but have all been captured, or added from without, and have had their orbits reduced in size and rounded up under the secular action of the nebular resisting medium. It may be demonstrated that it was this resisting medium and nothing else which has given the paths of the planets and satellites that beautifully round form which has always been equally admired by the astronomer, the geometer, and the natural philosopher.

To establish the truth of this proposition with entire clearness, let us first apply to the bodies of the solar system a criterion based on the mechanical principle of the conservation of areas, which was proposed by Babinet in 1861 (Comptes Rendus, Tome 52, p. 481, March 18, 1861). In the paper of Babinet here referred to it is shown that if ω be the sun's angular velocity of rotation with radius r, and ω' and r' the same quantities when the matter of this globe is expanded into a sphere of radius r'; then by the law of the conservation of areas

$$\omega' r'^2 = \omega r^2. \qquad (1)$$

As to the derivation of this formula it is sufficient to recall that the square of the radius is the same as that which appears in the moment of inertia of a rotating mass, and the product of this by the angular velocity ω gives the moment of momentum, which is always a constant in any free rotating system subjected to no forces except the mutual attraction of its parts. Thus

$$C = \sum m r^2 \omega = \omega \sum m r^2 = \omega' \sum m r'^2. \qquad (2)$$

In the case where the matter of the Sun is expanded to fill the orbit of the Earth, we take $r = 109{\cdot}5$, and $r' = 23445$, and get $\omega' (23445)^2 = \omega (109{\cdot}5)^2$.

And the time of the Sun's rotation, when the matter of that globe is expanded to the Earth's orbit, becomes

$$25^d{\cdot}3 \frac{\omega}{\omega'} = 25^d{\cdot}3 \left(\frac{23445}{109{\cdot}5}\right)^2 = 3192 \text{ years.} \qquad (3)$$

And when the matter of the Sun is imagined expanded to fill the orbit of Neptune, at a mean distance of 30, we have for the time of rotation of the hypothetical solar nebula

$$25^d{\cdot}3 \frac{\omega}{\omega'} = 25^d{\cdot}3 \left(\frac{30 \times 23445}{109{\cdot}5}\right)^2 = 2888533 \text{ years.} \qquad (4)$$

Adopting the system of constants for the solar system employed in the paper in A. N. 3992, with the latest results for the new satellites of Jupiter and Saturn, we find for the entire solar system the following table, which requires no further explanation.

Table Showing the Application of Babinet's Criterion to the Planets and Satellites, when the Sun and Planets are Expanded to Fill the Orbits of the Bodies Revolving about Them. SOLAR SYSTEM.

Planet.	*Ro.* The Sun's observed Time of Rev.	*Po.* Observed Period of Planet.	*Re.* Time of the Sun's Rotation Calculated by Babinet's Criterion.
Mercury . .	25·3 days = 0·069267 yrs.	0·24085 yrs.	479 yrs.
Venus . . .		0·61237 ,,	1673 ,,
The Earth . .		1·00000 ,,	3192 ,,
Mars . . .		1·88085 ,,	7424 ,,
Ceres . . .		4·60345 ,,	24487 ,,
Jupiter . . .		11·86 ,,	86560 ,,
Saturn . . .		29·46 ,,	290962 ,,
Uranus . . .		84·02 ,,	1176765 ,,
Neptune . .		164·78 ,,	2888533 ,,

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SUB SYSTEMS.

Planet.	Satellite.	R_0. Adopted Rotation of Planet.	P_0. Observed Period of Satellite.	R_c. Time of Planet's Rotation calculated by Babinet's Criterion.
The Earth	The Moon	1 day	27·32166 days	3632·45 days
Mars . .	Phobos	24h·62297	7·6542 hours	190 62 hours
	Deimos		30·2983 ,,	1193·52 ,,
Jupiter .	V.	9h·928	11·9563 hours	64·456 hours
	I.		1·7698605 days	14·60 days
	II.		3·5540942 ,,	36·900 ,,
	III.		7·1663872 ,,	93·933 ,,
	IV.		16·7535524 ,,	290·63 ,,
	VI.		250·618 ,,	10768·8 ,,
	VII.		265·0 ,,	11602·4 ,,
	VIII.		930·73 ,,	61997·2 ,,
Saturn .	Inner edge of ring	10h·641	0·236 days	0·6228 days
	Outer edge of ring		0·6456 ,,	2 383 ,,
	Mimas		0·94242 ,,	4·2902 ,,
	Enceladus		1·37022 ,,	7·0615 ,,
	Tethys		1·887796 ,,	10·822 ,,
	Dione		2·736913 ,,	17·751 ,,
	Rhea		4·517500 ,,	34 620 ,,
	Titan		15·945417 ,,	186·05 ,,
	Hyperion		21·277396 ,,	273·06 ,,
	Iapetus		79·329375 ,,	1580·1 ,,
	Phœbe		546·5 ,,	20712 ,,
Uranus .	Ariel	10h·1112 (*cf.* A.N. 3992)	2·520383 days	33·714 days
	Umbriel		4·144181 ,,	65·435 ,,
	Titania		8·705897 ,,	176·05 ,,
	Oberon		13·463269 ,,	314·83 ,,
Neptune	Satellite	12h·84817 (*cf.* A.N. 3992)	5·87690 days	141·8 days

It will be seen from a study of the remarkable data given in this table that the hypothetical solar nebula, when it extended to the orbits of the several planets, as imagined by Laplace, could not have rotated with sufficient velocity to detach any of these masses. This inference was already drawn by Babinet in 1861. Indeed, he first applied the criterion to the cases of the Earth and Neptune. I have developed the table to show moreover that none of the satellites could have been detached from their planets, and thus the argument against the detachment of the planets and satellites is complete and unanswerable.

By the logic of exact data based on a mechanical law of unquestioned validity and without any assumptions as to the law of internal distribution of density except that it remains unchanged, we are thus compelled to admit that the premise adopted by Laplace was false and unjustifiable, when he supposed that the planets were detached from the Sun, and the satellites detached from the planets, by acceleration of rotation. Thus this venerable explanation of the roundness of these orbits falls to the ground.

Now the planets and satellites could be formed in but one of two possible ways: (1) They might conceivably have been detached from the central masses which now govern their motions by accleration of rotation, as supposed by Laplace. (2) They might have been original nuclei captured in the midst of the solar nebula, and afterwards gradually built up by the agglomeration of more cosmical dust, while at the same time the orbital motion in this resisting medium would have reduced the major axes and eccentricities of their orbits, and thus produced the near approach to perfect circularity now observed in our solar system.

We have, however, just proved, by the application of Babinet's criterion, based on the law of areas, that these bodies could not have been detached from the central masses about which they now revolve. Accordingly, it follows that they were all captured, and have since had their orbits reduced in size and rounded up under the secular action of the resisting medium formerly pervading the planetary system.

From this unexpected conclusion there is absolutely no escape. For we may prove it by the following reasoning. The effect of a resisting medium in reducing the major axis and eccentricity of the orbit of the resisted body is fully recognised, and has been known for more than a hundred years. The formulæ for the changes of these two important elements may be reduced to the form

$$\delta a = -\frac{2a^2}{p^2(1+m)}\,[A'\,v + \text{periodic terms}] \qquad (5)$$

$$\delta e = -\frac{2}{p}\,[A\,e\,v + \text{periodic terms}] \qquad (6)$$

where p is the parameter of the orbit, a the semi axis major, e the eccentricity, v the true anomaly, and m the mass of the resisted planet, and A and A' constants. As both of these expressions are negative, it follows that under the secular action of a resisting medium the major axis and eccentricity always decrease. In deriving these formulæ, however, the density of the resisting medium is supposed to increase towards the centre, comformable to what is observed in the nebulæ and shown to result from the theory of gases.

Laplace himself has discussed this question with characteristic penetration in the Mécanique Céleste (Liv. X., ch. VII., § 19). He shows that when the density of the medium, represented by $\phi\left(\frac{1}{r}\right)$, increases towards the Sun, the semi axis major and eccentricity always decrease; and finally remarks: "Therefore at the same time that the planet approaches towards the Sun, by the effect of the resistance of the medium, the orbit will become more circular." It is surprising that it did not occur to the author of the Mécanique Céleste that the roundness of the orbits of the planets and satellites could be explained by a resisting medium quite as easily and simply as by the theory of a rotation which would gently detach these masses and set them revolving in orbits which are nearly circular, especially since the nebular hypothesis itself necessarily implies the existence of such a medium where the planets and satellites now revolve. Laplace merely remarks that if the nebula filled the whole of this space the bodies would encounter such resistance as to cause them to fall into the Sun; but in making this statement he overlooked the fact that most of the nebulous matter did go into the Sun and planets, and it is from this circumstance that the central masses became so preponderant, while the attendant bodies are in all cases so very small.

During a recent conference with my friend Professor George Davidson, I mentioned Laplace's proof that a resisting medium had formerly acted against Jupiter's satellites, I., II., III., to bring about a near approach to commensurability in their mean motions, and thus enable their mutual attraction to establish a rigorous relationship under the influence of this slowly acting cause. This venerable astronomer justly remarked: "Laplace had the true cause in sight, but he did not carry it far enough to discover the actual process by which the solar system was formed."

Evidently Laplace had not tested his nebular hypothesis by the criterion based on the conservation of areas, afterwards proposed by Babinet, and it simply did not occur to him that the circularity of the orbits pointed unmistakably to the secular action of a resisting medium.

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As the very existence of a nebula implies resistance to bodies revolving within it, this oversight is the more remarkable; and unfortunately not only was Laplace's reasoning vitiated, but an equally disastrous effect exerted on all other investigations in Cosmical Evolution for more than a century, because all mathematicians followed the same line of thought, on the false premise that the planets and satellites were detached from the central bodies which now govern their motions.

If in the light of this new theory of the shaping of the orbits under the secular effects of resistance we examine our solar system carefully, we shall find many phenomena confirming the former existence of such a medium in our system.

It must suffice here to call attention to but a very few of the numerous survivals of the primordial resisting medium still shown by our system:

(1) The rapid motion of Phobos, the inner satellite of Mars, which has been brought down near the planet by resistance, till it now revolves in less than a third of the time of the planet's rotation. It is true that Professor Sir G. H. Darwin explains this motion of Phobos by a tidal retardation of the axial rotation of Mars; but in view of the large part undeniably played by the resisting medium in the formation of our system as a whole this explanation will not hold, though a very small part of the observed effect may be traceable to tidal friction.

(2) The famous inequality in the motions of the three inner Galilean satellites of Jupiter, which point unmistakably to a resisting medium, as was sagaciously pointed out by Laplace in 1796. His remarks on this subject are as valid and convincing as any which could be made to-day.

(3) The observed rapid motion of the inner ring of Saturn, which greatly exceeds the axial rotation of the planet. The rings evidently were never detached from the planet, but simply survive out of a much larger mass of cosmical dust which has been absorbed in building up the mass of Saturn. All the data in the table relative to Babinet's criterion bear on this same question.

(4) The general fact that the satellite orbits are so round, and in general rounder and rounder the nearer we approach the planets, confirms the capture of these bodies in a medium which was denser towards these centres. The roundness of the satellite orbits shows that resistance was very effective from Mars to Neptune, and therefore no doubt throughout our whole solar system.

(5) The retrograde motion of Saturn's satellite Phœbe and Jupiter's VIIIth satellite is likewise to be explained by the capture of these bodies. Whatever may have been their original eccentricities at the time of capture, even retrograde directed bodies could have survived, because the medium against which they revolved was of very slight density at that great distance from the planets. This slight density of the resisting medium at this distance is also indicated by the survival of considerable eccentricities in the orbits of these two satellites. The eccentricity of the orbit of Phœbe is given as 0·22, that of Jupiter VIII. as 0·44, which are certainly anomalous enough to excite our suspicion. It is not by chance that retrograde motion in these two cases is associated with the highest eccentricities observed among all the satellites thus far discovered.

(6) The orbits of the Asteroids have been gathered into their present positions mainly by the action of Jupiter and of the resisting medium. Originally they were more widely distributed over the whole system than at present; but even now they overlap the orbits of Jupiter and Mars, and there may be others of still wider range.

(7) The extreme roundness of the orbit of Neptune is a clear indication that this planet moved for a long time against a vast amount of nebulous resistance. Therefore it is very improbable that our planetary system terminates with Neptune. In all probability there are several more planets beyond the present boundary of the system, some of which may yet be discovered.

(8) The equatorial accelerations noticed on the globes of the Sun and of Jupiter and Saturn are to be explained by the falling in of matter revolving in vortices about these bodies. As the orbital motion of this matter near these bodies exceeds that depending on the axial rotation, the falling particles necessarily produce an equatorial acceleration. This process may still be going on; at any rate, it has been in progress so recently that the effects still continue.

(9) The solar system was formed from a spiral nebula, revolving and slowly coiling up under mechanical conditions which were essentially free from hydrostatic pressure. And spiral nebulæ themselves arise from the meeting of two or more streams of cosmical dust. The whole system of particles has a sensible moment of momentum about some axis, and thus it begins to whirl about a central point, and gives rise to a vortex. In the actual universe the spiral nebulæ are to be counted by the million, and it is evident that they all arise from the automatic winding up of streams of cosmical dust, under the attraction of their mutual gravitation. The two opposite branches of the spiral nebulæ, so often shown on photographs, represent the original streams of cosmical dust which are coiling up and forming gigantic spiral systems.

(10) When the nebula rotates and the coils wind up in such a way as to leave open spaces between the coils, or at least freedom from sensible hydrostatic pressure, the usual result is the development of a system made up of small bodies, such as the planets compared to the greatly preponderant Sun, or the satellites compared to the much greater planetary masses which control their motions. In the solar system where the conditions are accurately known this is proved to have occurred; and it was repeated so many times always with uniform results giving a large central mass and small attendant bodies that the general law for this condition is clearly established.

(11) If the streams so converge that the nebulous mass becomes very concentrated at the centre, so as to become a figure of equilibrium under the pressure and attraction of its parts, the nebula may divide into a double star, as I have elsewhere inferred from the researches of Poincaré and Darwin on the figures of equilibrium of rotating masses of fluid.

(12) Now both of these forms of development are abundant in the actual universe, and probably almost all of the apparently single stars are surrounded by systems of planets. At least one fifth of all the stars are estimated to be double or multiple. If we assume the chances of the two forms of development to be equal we may calculate from the preponderance of small bodies actually found in the solar system—8 principal planets, 25 satellites (besides our Moon), and 625 asteroids—that the chances of a nebula devoid of hydrostatic pressure producing small bodies is about 2^{658} to 1, or a decillion decillion (10^{66}) to the sixth power to Unity $(10^{66})^6$. This figure is so very large that we shall content ourselves with illustrating a decillion decillion (10^{66}), and for this purpose we avail ourselves of a method employed by Archimedes to illustrate his system of enumeration. Imagine sand so fine that 10,000 grains will be contained in the space occupied by a poppy seed, itself about the size of pin's head; and then conceive a sphere described about our Sun with radius of 200,000 astronomical units (α Centauri being at a distance of 275,000), entirely filled with this fine sand.

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The number of grains of sand in this sphere of the fixed stars would be a decillion decillion (10^{66}). All these grains of sand against one is the probability that a nebula devoid of hydrostatic pressure such as that which formed the planets and satellites will lead to the genesis of such small bodies revolving about a greatly predominant central mass.

This is a very brief and inadequate outline of a few of the leading points in a very large investigation with which I am occupied. Most of these results were established over six months ago, and I have had opportunity to discuss them with several experienced astronomers. It is hoped that the whole investigation may appear as Volume II. of my Researches on the Evolution of the Stellar Systems; but it seemed advisable to communicate this brief summary of some of the most interesting points without further delay.

The effect of this work will be to give the Theory of the Resisting Medium the highest importance in all researches relating to the history of the Universe. It is very remarkable that the principal secular effects of this cause are exactly opposite to those due to Tidal Friction as investigated by Darwin. For while Tidal Friction usually increases the major axis and eccentricity of an orbit, the resisting medium as regularly decreases both of these elements. In the actual physical universe both causes are at work together, sometimes one influence predominating and then the other. Resisting medium is relatively most effective in a system made up of a large central sun and small attendant bodies, such as the planets of our solar system; and as the systems of satellites dominated by large planets. Tidal Friction is most effective in systems made up of two large masses, such as the double stars.

It has seemed advisable to call attention to the cause of the roundness of the orbits of the planets and satellites, because it appears likely that the criteria now introduced may go far towards clearing up the mystery which has always surrounded the origin of our solar system.

T. J. J. See.

U. S. Naval Observatory, Mare Island, California,
Jan. 1, 1909.

Note.—Since communicating the above paper on Jan. 1, 1909, it has seemed advisable to emphasize more strongly the conclusion that there is certainly one, most likely two, and probably three unknown planets beyond Neptune. In December, 1904, I examined the evidence bearing on the place of the planet next beyond Neptune and concluded that this body, which was then designated as Oceanus, was most likely near longitude 200°, and at a distance of 42·25, with a period of 272·2 years. Such a body harmonizes all known data, but the location in longitude is subject to considerable uncertainty. The longitude cannot be much smaller than this, but it might be appreciably larger. The other planets I have placed at distances of 56 and 72 respectively, but they will be much more difficult to discover than that situated between 42 and 44. In view of the light now thrown upon the mode of formation and constitution of the solar system I would recommend a persistent photographic search of the region of the ecliptic between longitudes 200° and 250°. Different persons will form different estimates of the validity of the grounds on which this extension of our solar system outward has been based, but I am satisfied that time will show the prediction to be well founded. To suppose the planetary system to terminate with an orbit so round as that of Neptune is as absurd as to suppose that Jupiter's system terminates with the orbit of the fourth satellite. The force of this analogy is not appreciably weakened by the fact that Jupiter's satellites constitute a sub-system of our solar system.

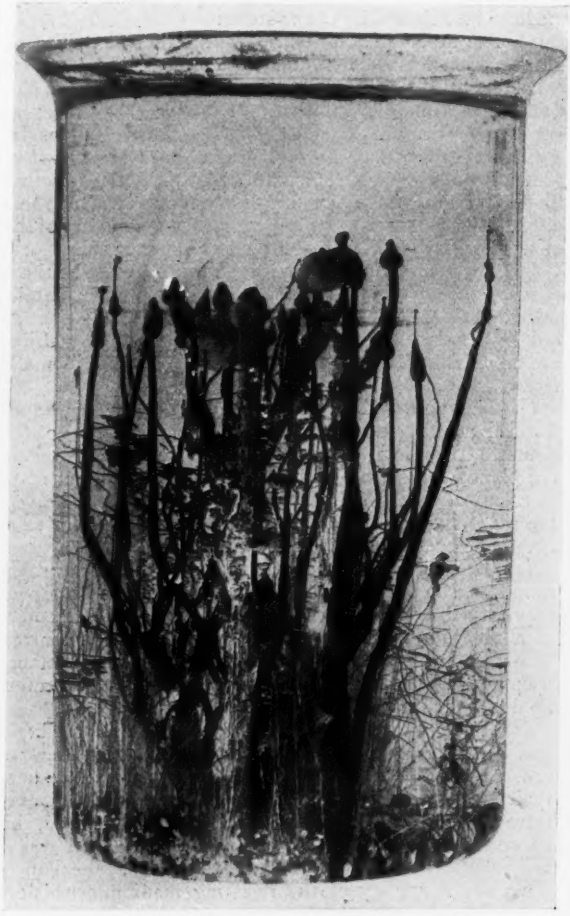
T. J. J. See.

U. S. Naval Observatory, Mare Island, California,
Jan. 10, 1909.

Osmotic Pressure and Living Cells.

Some Experiments with Solutions.

IN the very interesting chapter on the "Problems of Solution" which appears in Mr. W. C. D. Whetham's "The Recent Development of Physical Science" (John Murray) he defines the importance of this question. We quote from the newly-published second edition: "To one inexperienced in the problems which confront the workers in the world of natural science, the whole question of solution and its attendant phenomena may appear of small account. Yet the study of these

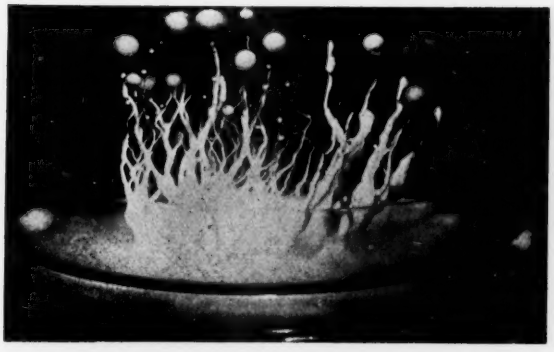


Osmotic growths of mingled kinds, produced by the described method of introducing differentiated sugar and metal solutions into a copper solution. Some of the rods which are thus induced to grow end in spheres, others in cones. The herbivorous appearance of some of the rods and tendrils is very noticeable.

phenomena and the unravelling of their intricate connections are of fundamental importance . . . More and more the reactions of inorganic substances, whether liquid or solid, are referred to their properties in a state of solution, while every process of life to be examined by the biologist seems capable of interpretation only through attention to the conditions thereby involved. Moreover, most chemical actions, especially those examined easily in the laboratory, occur between substances one or more of which are actually in the liquid

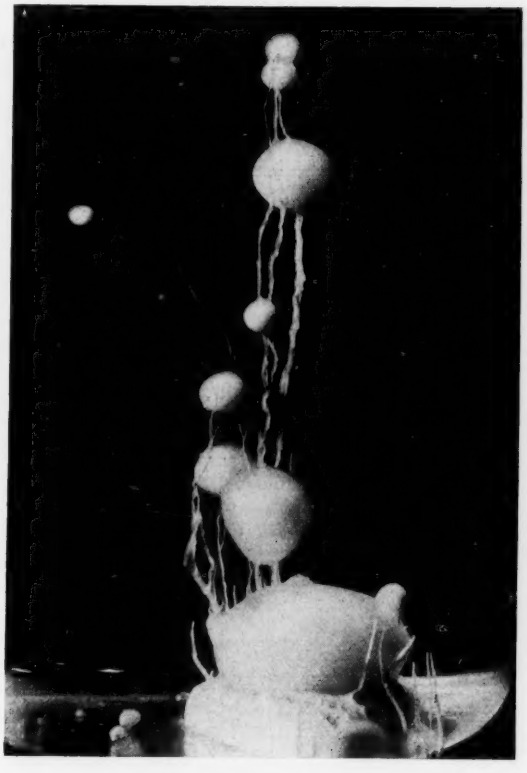
state; while the application of physical conceptions to the problems of living matter chiefly depends on the knowledge we possess of the physics and chemistry for ordinary solutions."

As long ago as 1877 Pfeffer, following on the researches



A plant-like chemical growth ending in spheres.

of Traube in the organic cells of plants and their semi-permeable membranes, discovered certain laws governing the osmotic pressure of solutions: that is to say the tendency of a solution to press against its surrounding membranes. In 1885-6 Van t'Hoff drew attention to the

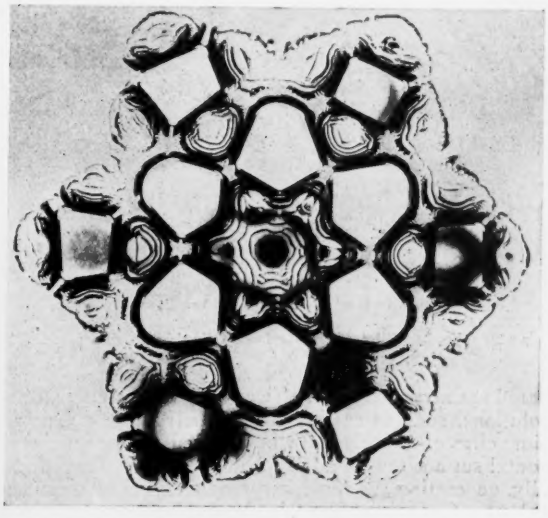


Sphere-like terminals of the growth.

importance of osmotic pressure and showed that (1) the osmotic pressure was inversely proportional to the volume in which a given mass of sugar was confined in solution and (2) that the absolute value of the pressure in the case of a solution of sugar was the same as that which would be exerted by an equal number of molecules of a gas when placed in a vessel having a volume equal to that of the solution. For instance, a quantity of gas of the same molecular concentration as a 1 per cent. solution of sugar would exert a pressure equal to that which Pfeffer had observed for the osmotic pressure of a sugar solution against the sides of a membrane-like receptacle containing it. Therefore dilute solutions appear to follow the same rule as gases; and the pressure depends on the number of molecules present, not on their nature.

Some of the more popularly illustrative results which have followed from the study of the interplay of solutions appear in the photographs made in the laboratory of Professor Leduc, of Nantes, which have been sent to us by Dr. Alfred Gradenwitz.

Dr. Gradenwitz writes: "Professor Leduc having introduced a drop of sugar solution containing traces of potassium ferrocyanide into a dilute copper sulphate solution, found, as Traube had found, that the drop of



A further development of a diffusion pattern.

sugar solution covered itself with a copper-ferrocyanide membrane, pervious to water but impervious to sugar. Physical conditions similar to those in a naturally germinating cell, within which there is high osmotic pressure and strong cohesion, were thus obtained, the contact of the potassium ferrocyanide with the copper sulphate producing a semi-pervious sheath. Under the influence of the difference in osmotic pressure between the drop and the liquid into which it is immersed, the water would percolate through the surrounding membrane which the sugar was unable to traverse. The cell would thus grow on, while, after the lapse of some minutes, from some point of its surface would spring up a bud. This would be surrounded immediately by a copper-ferrocyanide membrane. On the top of this bud would be produced another bud, and on this a third one, and so on, each bud constituting a cell, all of which would arrange themselves slowly in a continuous row, forming a hollow rod, the length of which would exceed by more than ten times the diameter of the original cell, of which the others were offsprings. The artificial cells absorbed from the surrounding medium the substance required for their growth, and thus produced the bulky growths exhibited.

A droplet would sometimes be projected in the course

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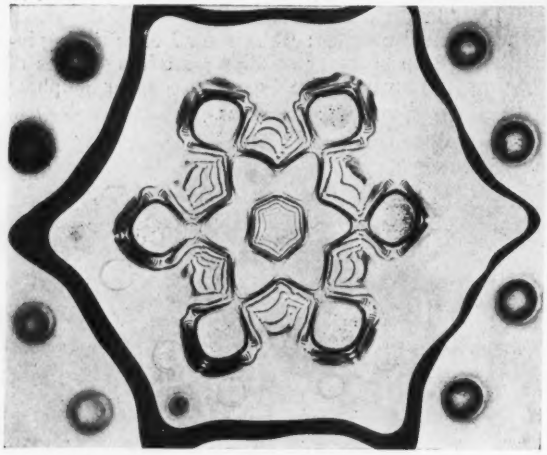
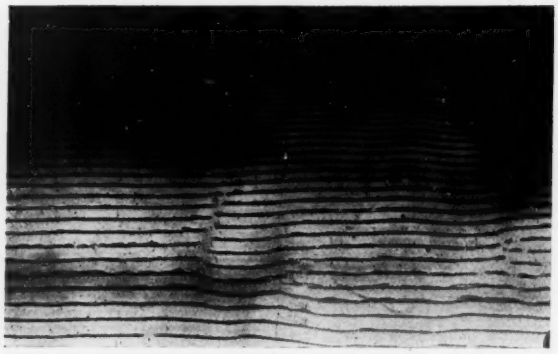
of the experiment, being entirely detached from the original drop, in order afterwards to grow on and give off buds and growing rods, which finally produced a form similar to the original one. At the recent exhibition of the French Physical Society, Professor Leduc showed a number of examples of the way in which the diffusion of solutions could be made to assume not only plant forms, but decorative patterns.

The following particulars will enable anyone to obtain similar figures of diffusion: On a glass plate are poured out five cubic centimetres of a 10 per cent. gelatine solution to which has been added a drop of a saturated solution of different composition (preferably ammonium chloride, bromide, or iodide). On the gelatine thus prepared are arranged symmetrically some drops of various solutions, such as calcium nitrate, silver nitrate, potassium citrate. If this plate be allowed to rest on a horizontal surface the liquid drops are seen to diffuse gradually, generating the most surprising effects of form and colour. Care should be taken to protect the plate when drying against any shock; the picture is eventually glued on paste-board, like a photographic print, in order to be used in practice as decorative pattern. Certain substances will produce by their diffusion lines of equal distance—alternately transparent and opaque—the thickness of which varies from some tenths to less than 1/1000 of a mm. If their thickness is intermediary between 1/100 and 1/1000 mm., the patterns are full of net-works of lines, and rectilinear or circular gratings, giving the most splendidly coloured diffraction spectra, are easily obtained. These gratings are obtained with a large number of substances; especially beautiful samples are produced by allowing a mixture of saturated solutions of potassium phosphate and carbonate in equal parts to diffuse. In fact, the effects then obtained are quite similar to the scintillation of mother-of-pearl.



A pattern produced by the diffusion of liquids on one plate. The droplets of other liquids are shown.

Now, as pointed out by Leduc, all living tissues show the same kind of network structure. In fact, not only in mother-of-pearl, but in the wings of beetles, feathers of birds, muscles and sinews of man, and in many other living substances, are met the same structure and colour effects whose production no physical force so far sufficed to explain. In addition to its scientific interest, the process above described is obviously of the highest practical importance, allowing as it does the most splendid pearly photographs to be produced by coating the gelatine of the photographic plate at 35° C. with a gelatine layer, containing traces of calcium nitrate on which drops of a mixture of calcium phosphate and carbonate are spread out.



A diffusion grating furnishing results similar to those of a diffraction grating.

Solar Disturbances During April, 1909.

APRIL has been marked by a fair amount of activity. The longitude of the central meridian was 104° 4′ at noon on April 1st.

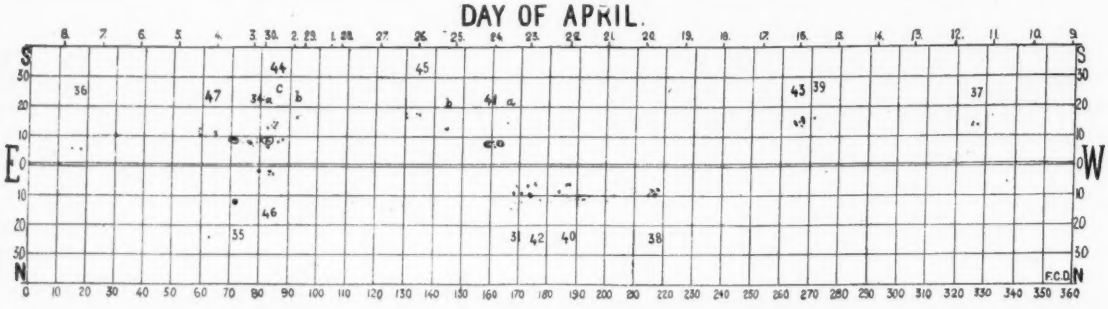
Nos. 31, 31*b*, 34*a*, and 35 having remained on the disc during the early days of April again appear on this chart.

No. 34*b*.—A tiny dot only seen on April 2nd.

No. 34*c*.—A group of minute pores on 4th, two or three remaining until 5th.

No. 36.—A very diminutive spotlet on 8th with some ill-defined pores near, became lost, and then revived again with very faculic surroundings on 12th and 13th.

No. 37.—A spotlet on 11th having its umbra bridged, with two or three tiny pores in a close group 15,000 miles behind it. These seem to have become lost, but revived in a faculic disturbance, 16th and 17th.



No. 38.—A solitary spot 14th to 17th, with a pore 26,000 miles in its rear 18th, pores connected the spot and pore 19th, as on chart 20th, a triangle of spotlets 21st to 23rd, the northern one nearly gone 23rd. On 24th a solitary pore, the place being marked by facula on 25th.

No. 39.—A tiny pore only seen 17th.

No. 40.—A group of three spotlets in a faculic area which is close behind the place of No. 28*a*, 17th-19th; a spotlet and minute pore 20th; a pore only 21st, which was only a gray marking 22nd when last seen.

No. 41.—A spot round limb, seen 18th, two pores east, one 75,000 miles distant, 19th, when the spot was 14,000 miles in diameter. The spot had lengthened on 22nd, showing three umbræ, with five pores following. By next day the long spot had separated into two, and the rear spot grown considerably, reaching 16,000 miles in diameter on 24th, and 22,000 miles on 25th. The group was 64,000 miles in length, but after 25th it dwindled until it reached the limb on 30th.

No. 41*a*.—A pore only showed on 24th.

No. 41*b*.—A tiny compact group of pores on 22nd, only two remaining until 23rd.

No. 42.—A very disturbed faculic area, in rear of No. 40, marked the site of No. 31. On 19th a group of spotlets and pores had developed, which underwent rapid changes in form, attaining a maximum length of 52,000 miles on 22nd, its breadth was 30,000 miles. On 23rd, between 7.45 and 8.30 a.m., it was the seat of a terrific outburst witnessed by Messrs. Buss and Dennett, dark hydrogen was projected towards the observer displacing the C-line toward violet twice the distance of the D-lines, indicating a velocity of quite 360 miles per second. After 8 o'clock the mass seemed to fall back upon the sun, displacing the line toward red. But only a single pore was visible on 24th and 25th.

No. 43.—A pair of spots the leader 19,000 miles and the trailer 12,000 miles in diameter, with pores between, broke out suddenly, in the area of No. 29, 21st and 22nd.

No. 44.—A pair of pores in faculic surroundings 24th-25th, four 26th to 28th, two pores 29th-30th, a pore after, which disappeared during the morning of May 4th.

No. 45.—A group of four pores 36,000 miles in length on 29th, a solitary pore after until May 2nd.

No. 46.—A group consisting of a spotlet and three or four pores 43,000 miles in length broke out on 30th, very protean in appearance until last seen on May 5th.

No. 47.—An elliptical outbreak first seen on 30th. Its largest spot, the leader, increased to 16,000 miles in diameter, the maximum length of the outbreak being 74,000 miles. Only the large spot and one or two pores May 4th and 5th, only the spot afterwards until last seen on 7th.

Some other minute outbreaks were seen which could not be measured, one a pore only seen on 16th near longitude 196°, latitude south 10°.

The chart has been constructed from the combined observations of Messrs. J. McHarg, A. A. Buss, E. E. Peacock, and F. C. Dennett.

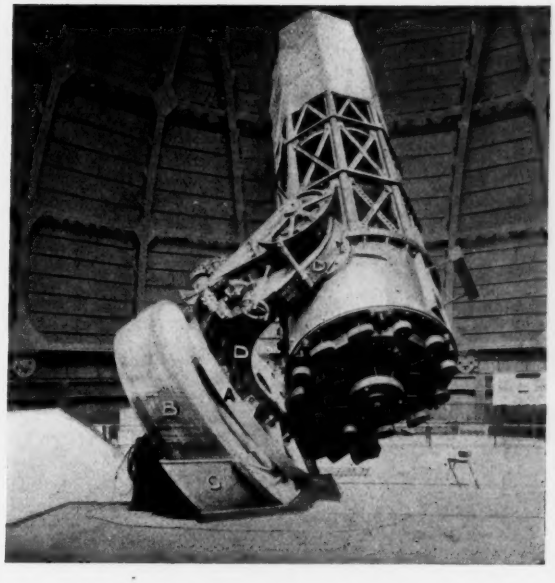
Mammals of the World, by W. F. Kirby, F.L.S. (London: S. Appleton, 1908; 6s. net).—If this book were thoroughly revised it might be made both a useful and reliable volume; in its present form it is neither, and is further marred by a number of particularly silly jokes. The Introduction could scarcely be more unsuitable, for it is practically a chapter on physiology, closing with an analysis of human urine! The plates, which are coloured, are, on the whole, passable.

NOTES.

ASTRONOMY.

By CHARLES P. BUTLER, A.R.C.Sc. (Lond.), F.R.P.S., F.R.A.S.

THE MOUNT WILSON 60-INCH REFLECTOR.—On December 13, 1908, the first visual tests of the performance of the great 60-inch reflector were made on stars at the Mount Wilson Solar Observatory in California, and on the 19th photographic records were obtained, from which it was at once evident that the new instrument was so nearly perfect as to satisfy all the expectations of its designer and constructor, Mr. G. W. Ritchey, optician of the observatory. The telescope is designed to be employed in four ways—(1) as a Newtonian, with a double slide plate carrier for direct photography and spectroscopic work; for this the focal length will be 299 inches (7.6 m.); (2) as a Cassegrainian, for direct



photography, having an equivalent focal length of 100 feet (30.5 m.), the enlarged image being formed at the north side of the tube near its lower end; (3) as a Cassegrainian for spectroscopic work on a large scale, focal length 80 feet (24.4 m.); (4) as a Cassegrainian-Coudé for spectroscopic work with a large stationary spectroscope at the bottom of the hollow polar axis in a constant temperature chamber; focal length about 150 feet (45.5 m.).

A specially interesting feature of the manufacture of this large mirror is that the grinding and polishing tools were only about one-quarter the area of the large mirror, the final polishing being completed with a 90° sector-shaped tool. In the early stages of parabolising the tests were made at the centre of curvature, but the final tests were made at the principal focus.

The mounting has been made very massive, as will be seen from the illustration, but the friction on the bearings of the polar axis has been relieved to a considerable extent by an ingeniously adapted mercury float. The greater part of the polar axis and its supports are below the floor level. At the head of the polar axis is a flange, A, 4½ feet diameter and 6 inches thick, to the lower side of which is bolted the float B, which is a very rigid, hollow cylinder of steel boiler

plate 10 feet diameter and 2 feet deep. This dips in a cast-iron trough C, which is machined to nearly fit the float, leaving a space of only $\frac{1}{8}$th inch all round; this space is filled with 650 pounds of mercury, the immersed part of the float giving a displacement of about 50 cubic feet, thus carrying $21\frac{1}{2}$ tons of the moving weight of the telescope. In this way about 95 per cent. of the weight on the bearings is taken up, and the mounting is so designed that the centre of weight is vertically above the centre of flotation. The gear wheel on the polar axis is 10 feet diameter, with 1,080 teeth. To the upper side of the flange A is bolted the massive fork D, between the arms of which the telescope tube swings in declination on nickel steel trunnions.

The telescope is provided with electric quick and slow motions, in both right ascension and declination, and the wiring is so arranged that these can be operated from several convenient points. The octagonal skeleton tube is built up of eight conical steel tubes about 15 feet long, with three rigid rings connecting them and the diagonal bracing. To carry the various secondary mirrors for adapting the instrument to any of the four types mentioned, four cages are provided which are fitted to the upper end of the skeleton tube. The double slide plate carrier is planned to take either 5 × 7 inch or $6\frac{1}{2}$ × $8\frac{1}{2}$ inch photographic plates.

A most elaborate system has been adopted for the building and dome, which is made to be quite air-tight. The outer skin has double sheet steel walls 2 feet apart, and all windows, doors, and the slit in the dome close against rubber packing. The dome is 58 feet diameter, with an observing slit 16 feet wide, which is operated by a 6-h.p. electric motor. The observing platform is suspended from the dome near the shutter opening, and is so arranged that all its motions are controlled by push buttons either from the platform itself or from the floor. An adjustable wind screen 17 feet wide and 35 feet long can be adapted to protect the telescope from wind or lights in the neighbouring valley.

To preserve the mirror as much as possible from change in temperature the building will be hermetically closed each morning, enclosing about 120,000 cubic feet of cool air, and it is hoped that this will remain cool during the day. After sunset the ventilating doors will be opened, and after a free circulation has been maintained, all will be ready for the commencement of observations.

Coming now to the actual performance of this mammoth reflector, it has been found that the figure of the 50-inch is notably superior to that of the 24-inch made by Mr. Ritchey at the Yerkes Observatory, which has provided such glorious views of the Andromeda nebula and other celestial objects. Combined with this we note that the mounting is so perfect that the star in the guiding eyepiece remains perfectly bisected on the spider lines for several minutes at a time, without perceptible tremor, and it is possible to see the star image so sharp and small that the diffraction pattern is as perfect as ever seen with the 24-inch.

From what we know of Mr. Ritchey's previous work we can now confidently anticipate such additions to our knowledge of the celestial bodies as will be worthy of the enormous expenditure and skill which have been necessary for the installation of so mighty an instrument of astronomical research.

OBSERVATIONS OF JUPITER.—Observations made by all the members of the Lowell Observatory staff at Flagstaff, Arizona, on 34 afternoons between March 28-June 4, 1907, indicate many interesting features. Chief among these were the wisps or lacings between the north and south equatorial belts, which have been described by Scriven Bolton. At the points where they connect with either of the dark belts there are to be seen spots of irregular shape and darker than the general run of the belts. At times the wisps go straight across, but usually they are inclined at an angle of about 45°, showing increasing curvature throughout their course; they show as irregular shreds of filament connecting the belts. The spots from which they proceed are caret-shaped, opening into the bright equatorial belt. They have been photographed by Mr. Lampland, but are very faint.

The colour of all the dark belts was a cherry red, deeper in some places than others, even the polar hoods showing tints of the colour at times. Dazzling white spots were also sometimes visible. The great red spot was dimly visible to the southern side of the hollow it forms in the south equatorial belt. A longitudinal line ran completely round the planet in the centre of the bright equatorial belt.

On March 30 the shadow of Satellite I. on the disc was observed to be elliptical, nearly twice as broad as it was high, and later on the same day a penumbra was visible to it. —(*Lowell Observatory Bulletin*, No. 38.)

Mr. J. H. Reynolds presented some very beautiful photographs of this planet at the Royal Astronomical Society, which he had obtained with his large coelostat reflector, 24 inches aperture and 38 feet focal length. The primary image was enlarged from 3-4 times with a Cooke negative lens. The photographs appear to show certain aspects of the general appearance of the planet somewhat more faithfully than drawings, although much microscopic detail is not present. The most marked characteristic of the photographs taken at the last opposition has been the lack of contrast between the belts and the zones, which contrast was very marked early in 1908. Visually the belts now appear of a light brick red colour, with the exception of the north equatorial belt, which is dark grey. It is intended to measure the position of the belts micrometrically, as there appears to have been some shift perceptible during the past year.—(*Monthly Notices Royal Astronomical Society*, Vol. 69, p. 511, 1909.)

LATEST VALUE OF THE SOLAR PARALLAX.— From the reduction of the photographs of Eros taken at the Cambridge University Observatory, Mr. A. H. Hinks announced at the Astrographic Conference at Paris that the resulting value of the solar parallax was 8″.807.

CHANGES ON SNOW CAPS OF MARS.—Professor Lowell announces, through the Kiel Centralstelle, that two rifts have been detected in the snow cap of Mars in longitudes 240° and 350°.

BOTANY.

By G. MASSEE.

LOCO-WEED.—Loco-weed, Astragalus mollissimus, Torr., and a few allied species, the cause of very extensive losses of live stock in the Western United States, has been investigated by Dr. A. C. Crawford (*Bull.* 129, *U.S. Bureau of Plant Industry*). After having definitely proved the toxic powers of the plant, it was afterwards discovered that the toxicity remained after boiling, and even in the ash after incineration. In experimenting with animals it was observed that the clinical and pathological symptoms following poisoning by Loco-weed closely resembled those produced by barium poisoning, and on investigation barium was found in the ash of many loco-weed plants in sufficient quantity to account for the symptoms. It was found that loco plants grown on certain soils contained no barium, hence did not prove injurious to cattle. In drying, the barium, when present, is apparently rendered insoluble in water, but can usually be extracted by the action of the digestive ferments. The barium, to prove injurious, must be present in such a form that it can be rendered soluble by digestion.

THE CALAVERAS NATIONAL FOREST, U.S.—According to *Science*, the forest contains about 1,400 Sequoias, perhaps better known as Wellingtonias, over six feet in diameter. Most of the larger trees are named after celebrated generals, statesmen, or States. The "Father of the Forests," unfortunately now fallen, measures over forty feet in diameter at the base. Some of these trees contain as much timber as fifteen acres of ordinary timber land.

THE MANUFACTURE OF TABLETS AND BRIQUETTES OF TEA IN CHINA.—The tablets and briquettes are made from black tea and green tea respectively. The black tea material consists of the siftings of the dried leaves prepared for tea as used in this country. The green briquettes and tablets are prepared from crushed fragments of stems and old and coriaceous leaves. The process of manufacture consists in first removing all sand and other impurities from the material, which is afterwards placed in moulds and subjected to hydraulic pressure of 136 kilogrammes to the square inch for a few seconds. The fine powder used in making tablets is compressed in the dry state, whereas the material used in making briquettes is subjected to a current of steam

for a short time before being compressed, to insure the cohesion of the coarser particles. For this reason the quality of briquettes is inferior to that of the tablets.

Considerable attention is paid to the composition and flavour of these condensed preparations, which appear to be as variable in flavour, aroma, and strength as the ordinary kinds of tea, and it is possible to obtain in this compressed form the finest productions of Ceylon, India, Java, and China, either apart or mixed in different proportions. When only one kind of tea powder, and that of a somewhat mediocre kind, is used, the tablets are often coated after the fashion of sugar-coated pills, with a layer of the highly perfumed Ceylon tea. It is considered that the most perfect method of preparing tea is embodied in the tablet method, which retains all the aroma. The tablets are each wrapped in silver paper, the briquettes in ordinary paper.

The countries favouring tea prepared as above are, more especially, China, Russia, Siberia, Mongolia, and Turkestan. A detailed account of the manufacture of tablets, etc., is contained in *Bulletin Economique*, Gouvernement General de l'Indochine.

CHEMISTRY.

By C. AINSWORTH MITCHELL, B.A. (Oxon.), F.I.C.

OCCLUDED GASES IN LAVA.—Specimens of lava emitted during the eruptions of Mont Pelée in 1902 and of Vesuvius in 1906 have recently been examined by Herr Grossmann to determine the nature and amount of gases they contained. In each case the finely divided material was heated in combustion tubing and the evolved gases collected in a vessel previously exhausted of air. The volumes of gas obtained from 100 parts by weight of the material were 2.5 cc. and 8 cc. from specimens of Mont Pelée lava, and 66 cc. and 65 cc. from Vesuvian lava. The gases from the former consisted chiefly of carbon dioxide (82 and 78 per cent.) with carbon monoxide (7.5 and 11 per cent.), nitrogen (5.4 and 6.6 per cent.), and hydrogen (5 and 2.1 per cent). The two specimens of Vesuvian lava differed much more widely as regards the proportion of occluded gases, their percentage composition being as follows :—

	Carbon dioxide.	Oxygen.	Nitrogen.	Carbon monoxide.	Hydrogen.	Methane.	Residue.
(1)	24·6	1·5	9·2	50·6	11·1	2·6	1·5
(2)	58·1	2·41	17·6	2·41	17·2	—	1·4

Traces of helium were detected in the Mont Pelée lava, and argon was present in one of the Vesuvian specimens, but rare gases were absent from the other.

In explanation of the different composition of the two kinds of Vesuvian lava it is suggested that the second one, that collected from Ottajano, consisted of older volcanic material, while the first was typical of the lava emitted in April, 1906.

MICRO-ORGANISMS IN SEWER AIR.—Many readers of "KNOWLEDGE" will recall an interesting paper by a former editor, the late Mr. A. C. Ranyard, in which the question of the occurrence of pathological micro-organisms in sewer gas was discussed (see "KNOWLEDGE." 1894, XVII., 57). The conclusion arrived at from the results of splashing experiments was that the air in sewers does not become infected with the bacteria in the sewage. The recent experiments on similar lines, however, made by Dr. F. Andrewes, and described in detail in a report to the Local Government Board, prove that such specific pollution of the air by the sewage does take place.

The characteristic streptococci found in sewage (*S. salivarius*) were repeatedly isolated and identified in cultures made on nutrient plates exposed to the air of sewers. Moreover, micro-organisms of the *B. coli* group were isolated from the air of a drain, and the biological characteristics of these agreed with those of the bacteria in the sewage itself. The fresh air in the immediate neighbourhood contained only a very small proportion of these bacilli.

In special experiments to determine the effect of splashing in ordinary house drainage, sewage was inoculated with *B. prodigiosus*, which forms a characteristic red growth on cultivation. The results showed that the ordinary amount of splashing was sufficient to separate the bacteria from the material passing through the pipes, and that a current of air could carry along with it these liberated micro-organisms for at least 50 feet in a direction opposite to that of the flow of the sewage.

INTERNATIONAL CONGRESS OF APPLIED CHEMISTRY.—The seventh international congress of applied chemistry is to be held in London from May 27 to June 2, and numerous papers that promise to be of interest are announced for reading and discussion in the various sections. Among the most important of the contributions from a public point of view may be mentioned a discussion on "Systems for the Control of the Food Supply by Analysis and Inspection," which will be opened by Dr. Buchanan, Chief Inspector of Foods of the Local Government Board; and another "On the Use of Preservatives in Foods," in which Messrs. Thresh and Bevan and several well-known foreign chemists will take part.

ACTION OF CARBON MONOXIDE ON METALS.—From the results of experiments published by M. G. Charpy in the *Comptes Rendus* it appears that nickel is not appreciably affected by carbon monoxide even at a temperature of 1,000° C., but that nickel oxide is completely reduced to metallic nickel at that temperature. Manganese and alloys of iron and manganese absorb the gas at 1,000° C., and subsequently give off part of it again, leaving a residue of manganous oxide and carbon. In like manner metallic chromium yields a mixture of carbon of chromium sesquioxide when treated with the gas at a high temperature. In neither case is any carbon dioxide given off during the reaction.

THE CAUSE OF "TACKINESS" IN RAW RUBBER.—It not infrequently happens that raw rubber develops an unpleasant "tackiness," the cause of which has been attributed to the action of micro-organisms or of enzymes preventing the coagulation of the latex or milky juice. Though it is possible that such agencies may play a part in the phenomenon, the experiments made by Mr. D. Spence indicate that their effects can only be indirect. The main cause appears to be a change which probably affects only the physical aggregation of the particles. Such changes frequently occur in certain varieties of rubber that have been coagulated with sulphuric acid. In experiments in which two portions of the fresh latex were sterilised by heat and incubated for a month at 35° C., one with and the other without the addition of acid, and the rubber then precipitated, it was found that the product in the preparation of which sulphuric acid had been used was very soft and deficient in strength. These results throw light upon the frequent deterioration of vulcanised rubber, which is injuriously affected to a pronounced extent by the presence of traces of free sulphuric acid.

GEOLOGY.

By EDWARD A. MARTIN, F.G.S.

BOULDERS OF THE CAMBRIDGE DRIFT.—A paper on the "Boulders of the Cambridge Drift," by R. H. Rastall, M.A., F.G.S., and James Romanes, B.A., was presented to the Geological Society on May 8. For several years past a large number of boulders have been collected from the Glacial drifts of Cambridgeshire, and from the post-Glacial gravels which have been derived from the drifts. These specimens have been classified geographically and then subjected to a careful petrological examination, with a view to the determination of their origin. Some special collections from Hitchin and Bedford have also been included for comparison. Rocks of Scandinavian origin, and especially those of the Christiania province, are abundant throughout the whole area: such well-known types as rhomb-porphyry and nordmarkite are common. Rocks from the Cheviots and Central Scotland are more abundant than was formerly believed, and specimens have also been identified from the Old Red Sandstone conglomerates of Forfarshire and from Buchan Ness (Aberdeenshire). Lake-District rocks probably also occur in small quantity. Much of the Chalk and flints appear to be of northern origin. It is concluded that an older Boulder-Clay, containing foreign erratics, the equivalent of the

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Cromer Till, once extended over the whole district, but was subsequently incorporated with the Great Chalky Boulder-Clay. The Scandinavian ice advanced from the direction of the Wash, bringing with it Red Chalk and bored Gryphæas from the bed of the North Sea, and carrying them as far west as Bedford. Rocks from the north of the British Isles become progressively scarcer from west to east, and the distinctive types are absent to the east of Cambridge. They appear to have been brought by an ice-stream coming from a northerly direction, which probably to a certain extent replaced the Scandinavian ice towards the east. In the discussion which followed, Professor Bonney remarked that the facts were very difficult to explain on any hypothesis, and he would only say that we must remember that, in the Glacial Epoch, the ice in the Scandinavian and the British areas would be likely to advance and retreat simultaneously. The paper, in short, was a very important one, and, as he well knew, had cost the authors much time and trouble. The Rev. E. Hill remarked that his own few observations fully agreed with the author's descriptions. The only point that he was inclined to question was the entrance of the boulders by way of the Wash. The Great Chalky Boulder-Clay seemed to have come from the west of the Lincolnshire Wolds into Norfolk and Suffolk, but to have found no exit by the Wash. The Yorkshire Clays which were continued east of the Lincolnshire Wolds, into the Cromer Till, seemed to have found no inlet by the Wash. If the Clays did not take this course, was it likely that the boulders should?

TRIAS IN THE CAUCASUS.—Dr. Felix Oswald, whose work on the Geology of Armenia we recently had occasion to notice, has contributed to the *Geological Magazine* some important notes on the discovery of triassic rocks in the Caucasus. He states that in 1903 W. I. Worobiev conducted an expedition into the Kuban territory of the Caucasus for the purpose of geological and mineralogical research, especially in the district between the Rivers Laba and Bielaya. Since W. I. Worobiev unfortunately lost his life on the Dzitak glacier the results of his journey have not been published. His collections, journals, and maps were, however, fortunately recovered by N. I. Worobiev in an unharmed condition, and are now in the possession of the Geological Museum of the Academy. Even a cursory examination of Worobiev's collection by Dr. T. Cernysev showed that it would cause a fundamental and essential alteration in the geological map of the Caucasus, and that in particular it would affect the composition, as hitherto known, of part of the Central Caucasus range. The most remarkable discovery, however, made by Worobiev was his finding beds of undoubted triassic age, which are characteristically represented in his collection; and an entirely new contribution to the geology of the Caucasus results from that part of Worobiev's materials.

COAST-GEOLOGY.—Mr. W. Whitaker's numerous contributions to geology during an active life of over 73 years are constantly being added to, and his bibliography, printed in the *Geological Magazine* some years ago, is constantly being increased. He has recently published separately a report, furnished to the Coast Erosion Commission, on the Geologic Conditions affecting the Coasts of England and Wales. During a long series of years, he says, he has examined a large amount of the English coast, either in the course of his work on the Geological Survey or in his holidays. This includes walking along the whole or nearly the whole coast of the following counties:—Norfolk, Suffolk, Essex, Kent, Sussex, Hants, Dorset, Devon, and Cornwall; a continuous series from the east to the south-west. To these may be added the small amount of coast possessed by Cheshire. He has also examined a considerable part of the coasts of Durham and Yorkshire as well as parts of the coasts of Somersetshire, Glamorganshire, Lancashire, and Northumberland. Generally speaking, every chance of seeing our coast has been taken. In some cases his walks were along the foot of the cliffs, in others along the top, often along both, and to many parts repeated visits have been paid. These facts are noticed in order to show that he has had some experience of the subject. In regard to the accretion of land, his remarks are valuable. "It is well known that there are various tracts where the land is gaining on the sea, and these are often instanced as if they more or less balanced the loss of land in other places. That they do this in the matter of area cannot be questioned; but I venture to say that this is all; that is to say, they do not, as a rule, in any way assist in the protection of the higher land against the destructive coastal actions. The fact is that almost all the gained land is below high water mark, and is largely protected artificially by banks."

A BROADER VIEW OF NATURE.—The Nature Study Society is holding an Exhibition on June 4 and 5 at the Botanic Society's Gardens in Regent's Park. From the prospectus it appears that living animals only are to appear among the exhibits. But Nature Study is not confined to living animals. Fossils, the animals of the past, surely deserve a place. While wishing the Exhibition success, we also hope that a broader view of Nature may prevail in future in the ranks of the Society.

BY AIRSHIP TO THE POLE.—If the Poles alone were the object to be aimed at, success in this direction might be achieved by M. Wellman. But we cannot study geology very well from a balloon.

METEOROLOGY.

By WILLIAM MARRIOTT, F.R.Met.Soc.

THE ANTI-CYCLONIC BELT OF THE NORTHERN HEMISPHERE.—Colonel H. E. Rawson read a paper on this subject at the meeting of the Royal Meteorological Society on May 19. In a previous communication he brought forward some facts regarding the anti-cyclonic belt of the southern hemisphere, derived from an examination of the South African records from the year 1841 to 1906 (see "KNOWLEDGE," May, 1908). He found that the indications of a cyclical oscillation of the belt to and from the equator over South Africa were strong enough to encourage the belief that an analysis of Australian records on the one side and of Argentine on the other would prove that all the action-centres of the atmosphere were moving together over this wide area, and that a similar oscillation existed in the northern hemisphere. Colonel Rawson subsequently found that the investigations of Mr. H. C. Russell, F.R.S., and of Dr. J. W. S. Lockyer supported his conclusion that there is a period of about 9.5 years between the greatest north and greatest south position of the anti-cyclonic belt in the southern hemisphere, the double oscillation thus taking 19 years. He has since extended the enquiry into the movements of the action-centres in the northern hemisphere with a view to ascertaining whether they show any similar oscillation to and from the equator, which is not to be explained by seasonal changes of position. Dealing with the Nile floods, he draws the inference that the high-pressure systems which affect North-East Africa are farther north when the floods are in excess, and nearer to Egypt when they are deficient. He has also made an analysis of the tracks of the hurricanes which passed north and south of Manila Observatory, and found that these throw an interesting light upon the oscillations of the action-centres of the atmosphere.

THUNDERSTORMS IN GERMANY.—The Royal Prussian Meteorological Institute has published a discussion, by Herr T. Arendt, of the thunderstorm observations made in North and Central Germany during the 10 years 1887-1896. The number of stations from which returns were used, and also the average number of thunderstorms per station in each of these years, were as follows:—

	Stations.	Thunderstorms per Station			Stations.	Thunderstorms per Station.
1887	1100	14.8	...	1892	1418	26.9
1888	1338	21.0	...	1893	1403	27.2
1889	1321	32.2	...	1894	1376	27.7
1890	1241	30.5	...	1895	1345	32.2
1891	1437	33.2	...	1896	1331	29.7

The month with the largest number of thunderstorms is July; then follow, in order, June, August, and May. January is the month of least thunderstorms. The time of the greatest frequency is between 3 and 5 p.m. There are, however, secondary maxima between 8 and 10 p.m., and also in the early morning hours.

HUMIDITY IN COTTON-WEAVING SHEDS.—The Departmental Committee which the Home Secretary appointed to enquire into the subject of Humidity and Ventilation in Cotton-Weaving Sheds have issued their Report. Among their recommendations are the following relating to humidity :—

1. That in view of the generally expressed opinion of physiologists that the health and comfort of the workers is dependent on the wet-bulb temperature rather than on the dry-bulb temperature, or the relative, or the absolute humidity, a limit of temperature on the wet-bulb thermometer be fixed at which all admission of artificial humidity shall cease, this limit to be decided by early experiments and to be the lowest necessary for efficient weaving.

2. That the present schedule of humidity be amended by eliminating all temperatures above the maximum wet-bulb reading to be hereafter determined and all temperatures below 50° F. on the dry-bulb, and that a minimum difference between the readings of the dry and wet bulb thermometers be fixed when the maximum wet-bulb temperature has been decided.

3. That in order to secure general confidence, the reading of the thermometers to be taken jointly by representatives of the employer and employed, and that a statement relating to the readings be entered in a register to be kept at the works and to be examined by H.M. Inspectors of Factories, but that records be sent to the Home Office only when irregularities are found, and the practical details be settled by conference between official representatives of the Manufacturers' and Operatives' Associations.

4. That power be given to the Secretary of State to prescribe a standard hygrometer, that distilled water only be used, kept sufficiently long in the shed to acquire the shed temperature, and that provision be made to prevent the wet-bulb moisture affecting the dry-bulb thermometer.

RAVAGES BY WHITE ANTS AT AN OBSERVATORY.—Mr. N. A. F. Moos, the Director of the Bombay and Alibág Observatories, in his Report for 1908, says that the grounds and buildings at Colaba are generally in as satisfactory a condition as can possibly be expected, seeing that apart from the observers' quarters the premises are very old—over 80 years. The ravages of white ants continue apace, and considerable Government and private property has been damaged, including a small portion of valuable magnetic records. Though precautions have been taken to provide glass insulators filled with kerosine oil for all the presses containing the records, it is doubtful if they will prove efficacious.

The method which Mr. Moos adopts for keeping his staff punctual when on duty is described as follows :—"The watchmen and observers continue the practice of recording their attendance on duty upon one of the photographic registers; the watchmen, who go round once every hour, night and day, to see that the clocks are all going and the lights burning, effect this by pulling out and putting in a stop on the box of the barograph at alternate hours; the observers mark, in a similar manner on the pluviograph register, the times both of commencing and concluding each of the six sets of observations made daily."

ORNITHOLOGY.

By W. P. PYCRAFT, F.L.S., F.Z.S., M.B.O.U., &c.

DUAL NESTING.—Miss E. L. Turner, in *Country Life*, May 22, relates a most interesting case of dual nesting which she kept under observation for some days. It seems that a Thrush and a Blackbird selected the same nesting site, and shared the work of building, or, more probably, prosecuted this work in each other's absence, and similarly fulfilled the task of laying and the early days of brooding. But, "as the hatching time came near, the intervals of leaving the nest grew shorter and fewer, and so the weaker species was gradually choked off, to be finally driven away when the young actually appeared." At any rate, though Miss Turner was assured the Thrush was often seen on the nest, she saw only the Blackbird. One Thrush and four Blackbirds were hatched out, but on the tenth day the Thrush was ejected, and was found dead at the foot of the tree in which the nest was placed.

THE BIRDS OF FAIR ISLE.—For some years Mr. W. Eagle Clarke has been keeping watch and ward over Fair Isle—midway between the Orkney and Shetland Islands—and this for the purpose of studying the movements of migrants. His results have been remarkable, and his latest report is the most remarkable of all. This report appears in the last issue of the "Annals of Scottish Natural History." Too long to review here, let it suffice to say that the following rarities were either obtained or observed in passage during 1908 :—Barred, Sabalpine, Icterine, and Savi's Warblers; Alpine Accentor, Blue-headed Wagtail, Red-throated Pipit, Richards Pipit, Golden Oriole, Hawfinch, Two-barred Cross-bill, Rustic Bunting, and Rose-coloured Starling.

BRUNNICH'S GUILLEMOT IN THE FIRTH OF FORTH.—The issue of the "Annals of Scottish Natural History" just referred to contains also a record of the occurrence of Brunnich's Guillemot (*Uria bruennichi*) in the Firth of Forth. The bird, a female, was picked up dead on the shore at Craigielaw Point on the Haddingtonshire coast of the Firth of Forth on December 11, 1908. It was apparently an immature specimen. This makes the fourth occurrence of this species in Great Britain since 1895.

GOLDEN ORIOLE IN CO. WEXFORD.—The *Field*, May 1, contains a record of a Golden Oriole, which was *seen*, and not shot, we are happy to note, by Mr. M. D. Haviland on April 15. High winds (S.E. to S.W.) prevailed, Mr. Haviland remarks, from April 21 to 23.

HOOPOES IN SURREY.—Mr. Arthur Mead, in the *Field*, April 24, records the fact that he had the good fortune to see, and to keep under observation for some time, two Hoopoes near Headley. The birds, he remarks, were evidently a pair. It is to be hoped they will escape that pest, the "collector of rare British Birds."

A PIED BLACK-COCK.—A most interesting specimen of a Pied Black-cock has just been presented to the British Museum of Natural History by Mr. G. Ashley Dodd, the bird being marked all over with crescentic bars of white, save on the head and neck, where these markings take the form of white flecks. The quills of the wing and tail are normal. Varieties of this kind are very rare in this species. The bird was shot in Wigtonshire.

PHYSICS.

By PROFESSOR A. W. PORTER, B.Sc.

METALLIC FILMS DEPOSITED BY ELECTROLYSIS.—When metal films are deposited above a certain thickness it is well known that they tend to peel off. Nickel, for example, curls up into beautiful close rolls, especially if it does not adhere tightly to the body upon which it is deposited. This has been found to be a great drawback in producing metallic mirrors by electrolytic deposit on glass. This phenomenon has been recently investigated by Mr. Gerald Stoney, who finds that when nickel is deposited on one side of a thin sheet of metal very considerable bending takes place, indicating that the nickel is in a state of tension, thus confirming some earlier experiments of Dr. E. J. Mills. Thin steel rules 102 mm. long, 12 mm. wide, and .32 mm. thick were varnished on one side and coated with nickel from the usual bath of ammonia-sulphate of nickel, and it was found easy to get these to bend to an extent of 3 or 4 mm. The thickness of the film was determined by weighing the steel before and after producing the deposit, and thence the tension can be calculated. In the case of films varying from .0056 mm. thick to .0264 mm. thick deposited at ordinary temperature, the tension comes out about 18 or 19 tons weight per square inch. When the deposition is effected at a temperature of 80° or 90° C. the tension falls to about half this value. It was also found on heating these rules to a red heat so as to anneal them that they straightened out to a considerable extent, the remaining deflection being only about one-third or one-half of the original.—(*Proc. Roy. Soc.*, No. A553.)

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LIQUID EMANATION.—Professor Rutherford, extending his work on the temperatures of condensation of radium emanation at various pressures, has obtained the following results :—

Vapour Pressure.	Temperature.
76 cms.	-65° C.
25 ,,	-78° ,,
5 ,,	-101° ,,
·9 ,,	-127° ,,

He finds, unexpectedly, that when the pressure is kept constant, the emanation does not all condense when once it has started; a considerable increase in the pressure is necessary to produce a complete condensation. He finds that after pumping off the uncondensed part that this has a slower rate of decay than the part condensed. Therefore, he leans to the idea that the emanation is not a single substance; but this point is still under examination. From measurements of volume in the gaseous and liquid states he obtains the value 5 for the density of the liquid, assuming that the atomic weight is about 222.

THE SODIUM SPECTRUM.—Professor R. W. Wood has extended our knowledge of those lines of the sodium spectrum which can be represented by a Balmer's series. Some little time ago he increased the number known to 24; he has now been able to count 48 such lines, and there are indications that higher resolving powers would bring more into view, for the head of the band is clearly indicated, though it is not so far resolvable into lines. He has succeeded in obtaining these results by employing the large quartz spectrograph at the Bureau of Standards (U.S.A.), which was placed at his disposal by the director of the Bureau (Dr. Stratton). It was found that a good deal depended upon getting the sodium vapour at just the right density. The colour of the transmitted light was deep violet, but if the vapour became too dense a general absorption appeared in the ultra-violet which spoiled the spectrum.

The series which represented well the *seven* lines known for some time is $10^8\lambda^{-1} = 41{,}496.34 - 127{,}040\ n^{-2} - 843{,}841\ n^{-4}$, but with the complete series now known the constants will require to be calculated anew.

One point of great interest to which Professor Wood calls attention is the general absorption with very dense vapour—an absorption which begins exactly at the head of the Balmer series and extends from this point down to the end of the ultra-violet.—(*Astrophysical Journal*, March.)

ZOOLOGY.

By R. LYDEKKER.

THE REVOLT AGAINST PRIORITY.—An echo of Mr. Boulenger's protest against the replacement of well-known scientific names of animals by obscure terms raked up from forgotten, and for the most worthless, works, and, above all, the transference of a name long held by one animal to another, resounds from America; and as that country is the hot-bed of the priority craze, there seem hopes for a change of opinion in the near future. The protest has been raised by Mr. Frank Springer, in a paper published in No. 1664 of the *Proceedings* of the U.S. National Museum. It is there stated that there are reasons either for abolishing or for transferring to another species the name *Encrinus liliiformis*, which has been in use for a century or so. The author states, however, that he will be no party to any such change; the name having acquired an indefeasible title by long usage in its present sense; this being precisely what I myself have urged in other cases. "In this way," he observes, "by analogy to the practice which prevails in courts of justice concerning the most solemn rights of property, a presumably just conclusion can be reached independent of the rule of priority, and without impairing its force in cases to which no such considerations of public policy apply."

COLOUR IN THE WEASEL TRIBE.—It has frequently been observed that in a large number of members of the weasel tribe—notably in the ratels of India and Africa—the ordinary type of mammalian coloration is reversed, the upper surface of the body being light and the lower dark. There the matter ended, so far as naturalists generally are concerned. Mr. Pocock has, however, recently pointed out that as the white-bellied type of colouring is undoubtedly for the purpose of rendering the animals in which it occurs inconspicuous, it is only logical to infer that the black-bellied type is to render animals as conspicuous as possible. And he supports this most obvious conclusion by demonstrating that most, if not all, of the black-bellied members of the weasel tribe have the power of producing a more or less evil odour, thus rendering them unsuitable as food for other animals.

A NEW ORGANISM.—In a recent issue of the *Proceedings* of the Royal Society of Victoria, Professor Baldwin Spencer has described a new marine organism, whose systematic position cannot yet even be guessed. It is a small, jelly-like, globular creature, which at first sight seems to present a resemblance to the Ctenophora, although closer examination shows that the structure is entirely different. The describer suggests that the problematical organism may prove to be a nursing-stock of some unknown form.

SEA-ELEPHANTS.—Everyone interested in animals should lose no time in paying a visit to the Natural History Museum in the Cromwell Road, in order to see the group of elephant-seals which have just been installed in the large case in the lower mammal gallery. They comprise the male and female of both the northern and southern species, and form an altogether unique exhibit.

PAPERS READ.—At the meeting of the Zoological Society, held on May 11, a paper by Professor W. Ridgeway on quaggas and zebras, another, by myself, on a race of the hangul deer of Kashmir from Sze-chuen, and a third, by Mr. E. C. Chubb, on the batrachians and reptiles of Matabililand, were read. To the meeting of May 25 I contributed a paper on a race of the Indian black bear from Eastern Tibet, and a second on the local races of the southern sea-elephant, while Mr. de Man described a new species of *Alpheus* from Batavia Bay, and Mr. Burne discussed the anatomy of the olfactory organ of fishes.

SERIALS RECEIVED.—From the University of California we have received copies of an article by Mr. H. B. Torrey on the Leptomedusæ of the San Diego Region, and of a second, by Dr. J. Grinnell and others on the birds and mammals collected by an expedition to south-eastern Alaska financed and headed by Miss Alexander. Both are issued in the Zoological Publications of the University. Several new kinds of jellyfishes are described in the first; while the second contains an account of a large series of species of which specimens were collected during the expedition. We have to acknowledge the receipt of copies of the *Victorian Naturalist* for March, and of the *Naturalist* for April. The contents of the former include reports of excursions to various parts of Australia and notes on living specimens of the rare parakeet *Psephotus dissimilis*. Among the items in the April *Naturalist*, reference may be made to an illustrated account of the phytoplankton of the English Lake District by Messrs. W. and G. S. West, and to the description of a wholly white crow recently killed in Yorkshire.

REVIEWS OF BOOKS.

ASTRONOMY.

Remarkable Eclipses, by W. T. Lynn. Tenth Edition (London : Samuel Bagster and Sons, Ltd., 1909).—The issue of a tenth edition of this handy volume is probably sufficient indication of its usefulness to the astronomical reader. In this case we have a thorough revision, the account of the total solar eclipses including a short notice of the last expedition to Flint Island in 1908, and recent research dealing with ancient eclipses is also noted. We can recommend the book to readers wishing to gather a general idea of these solar and lunar phenomena without the more technical accompaniments of the official publications.

BIOLOGY.

Germ Life: Bacteria, by H. W. Conn (London : Hodder and Stoughton, 1909; pp. 1-207, illustrated; price 1s. net).—In some degree, at any rate, this little volume seems to be misleading, for while the date 1909 appears on the

title page, the preface is dated April, 1897; while in the text the author speaks of the present century when he refers to the nineteenth century, and by the expression "fifteen years ago," he means from 1897. Whether the volume is merely a reprint of a previous edition, or whether its publication has been delayed for a dozen years, we are unaware, but in either case this should have been clearly stated. Premising, then, that the work cannot apparently be regarded as an up-to-date account of bacteria, it may be commended as a well-written, popular summary of the leading features in our knowledge of those ubiquitous and lowly organisms up to the year 1897. There is a popular belief that bacteria are altogether harmful, but this idea the author is careful to contradict, and he shows in how many ways—more especially in the restoration of nitrogen to the exhausted soil—how essential they are to the continuance of life on our globe. Mr. Conn has, indeed, managed to convey a wonderful amount of information within a very small compass.

CHEMISTRY.

Essays, Biographical and Chemical, by Sir William Ramsay, K.C.B., F.R.S. (London: Constable and Co.; pp. vii. and 247; 7s. 6d. net).—The majority of books on the subject of chemistry must unfortunately be classified with what Lamb describes as *biblia abiblia*, or books that are not literature. Rarely, indeed, is there scope for doing more with a chemical book than writing it in good English, and only when the subject is of more than merely scientific interest, as in the case of the present book, does the writer have a chance of showing his possession of a literary gift. In these essays Sir William Ramsay affords a proof that literary style need not always be divorced from chemistry, and that, apart from being fertile himself in imagination, he is able to appeal to the imagination of others. Both sections of the book will be found full of interest, even by those who have little or no knowledge of chemistry. The first part is chiefly devoted to biographical sketches of great chemists of the past, including Boyle and Cavendish, Davy, Graham, and Black, and brings out in clear relief the influence of each upon the development of the science. In those pages dealing with Lord Kelvin and the great French chemist, Berthelot, the reader will feel the influence of that personal knowledge which is essential for the touches that make a man live again in biography. The second part of the book deals with more purely chemical subjects, and, like everything written by Sir William Ramsay, is stimulating and full of suggestion. Among the subjects discussed may be mentioned: "The Becquerel Rays," "The Nature of an Element," "Radium and its Products," "What is Electricity?" and "The Aurora Borealis." The work concludes with an address given at University College on "The Functions of a University," in which a powerful plea is made for the pursuit of knowledge as an end, apart from its acquirement for technical purposes. Any one interested even remotely in chemistry who glances through this book will be anxious to obtain it and give it a permanent place on his shelves, for it will repay careful study.

NATURAL HISTORY.

The Moths of the British Isles, by Richard South, F.E.S. Second Series (London: F. Warne and Co.; 7s. 6d. net).—We have already spoken in terms of the highest praise of this work when reviewing the two preceding volumes. Mr. South now brings his task to an end, and when we say that this last volume in every way sustains the remarkably high standard set by its predecessors we shall but endorse the view of all who have possessed themselves of this work. The coloured illustrations are beautiful, and should enable the identification of captures an easy matter indeed. The uncoloured plates of caterpillars—all in characteristic attitudes—are no less admirable. Mr. South's records of rarities are very complete, but we are glad to be able to add one to the list given of captures of the beautiful Clifden nonpareil, for we had the good fortune to take a specimen in Norfolk in September, 1906. We are sorry that the author could not see his way to add the Latin names to the plates, for this omission is a really serious drawback to the usefulness of his work, and a further improvement would be the addition to the plate of the page whereon the text will be found to the species figured; while in the text-references to the plates the addition of the page where the particular plate will be found would save much time in reference. We sincerely trust that in future editions these suggestions will be adopted. But these, after all, are but minor points, and it is seldom, indeed, that a critic is afforded so little to grumble at. This volume contains no less than 873 coloured figures, while the uncoloured drawings of eggs, caterpillars, chrysalids, and food-plants cannot, at a guess, fall far short of this number. The size and binding of the volume leave nothing to be desired; it is, indeed, as we have proved by experience, an ideal book for a holiday collecting trip. It deserves to be, and doubtless will become, the most popular book of its kind in this country.

W. P. P.

PHYSICS.

Heat and Other Forces, by Colonel W. F. Badgley (London: King, Sell, and Olding, 1909).—In his appendix the author of this book remarks that he has been under the disadvantage of having no one to seriously criticise his work as he turned it out—no one to say, "This is not very clear," or "How do you arrive at that?" We regret that Colonel Badgley is in this isolated position, for we feel sure that much of this book—even the greater part of it—would not have been written if only he had had the benefit of a few friendly talks with someone more acquainted with the nature of scientific evidence and possessing greater knowledge of scientific facts. We deplore the fatal facility with which, on the strength of reasoning of the most meagre character, men rush into print and endeavour to alter the trend of scientific thought. "Ideas," he says, "like fashions, change." Well, it is the glory of science that they do so change. But it is its glory also that this change shall only take place as the discovery of fresh facts makes the old theories and explanations insufficient. Even then, no doubt, the change is often of a revolutionary kind. No better instance could be adduced than the alteration of point of view associated with the discovery of radium and the attendant phenomena. No doubt also much speculation is made in trying to explain phenomena to which, as yet, no explanation has been given. But the easy way in which our author puts aside the usual scientific explanations of familiar phenomena and replaces them by unsupported statements of his own is not such as to secure that any serious attention shall be directed to his efforts. This is a pity.

First-Year Physics, by C. E. Jackson, M.A. (London: Methuen and Co., 1908; 1s. 6d.).—A first-year text-book suitable for secondary schools in which three or four hours per week are available for this subject. It is mainly experimental in character. The experiments are well chosen; but we cannot point out any great novelty of treatment. The theoretic part, which is intended to form the basis of work in the lecture room, is usually quite simply and lucidly given. The definitions are not always such as please the reviewer. The explanation of the nature (or rather the non-nature) of force is far too metaphysical for the junior mind. The reviewer has found it to be rather too much for himself. Yet he is pleased with the book in the main.

MISCELLANEOUS.

Turbines, by Engineer-Commander A. E. Tompkins, R.N. Romance of Science Series (London: Society for Promoting Christian Knowledge; 3s. 6d.).—Although this volume does not deal with the romance of science in the way some others in the series do, and therefore its inclusion in the same series is not easily understood, it is nevertheless a very acceptable book. It is an attempt to deal in popular language with the principle of both water and steam turbines, their general construction and arrangement, and the essential details of recent naval practice. This is not at all an easy task, especially as regards the steam turbine, and in spite of the simplicity of his descriptions it will probably only be the mechanically minded who will make much of it. But for such, the clear descriptions, aided by the very clear illustrations, will provide a very excellent introduction to the subject.

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MICROSCOPY

Conducted by F. SHILLINGTON SCALES, M.A., F.R.M.S.

Low Power Photography for Delicate Unfixed Embryos.

THE photography of objects, such as embryos, which possess considerable thickness, offers several difficulties even with low powers. In such work it is usual to suspend the object in fluid and to use a very low power objective. Professor C. J. Patten, of Sheffield, contributed to the *British Medical Journal* of August 29 last an interesting account of his methods of photographing a large number of embryos for class and other purposes. He had found "fixation" processes caused more or less shrinkage and distortion in the embryos, and, moreover, made the object quite opaque instead of preserving its natural striking transparency, and this even when the baths were made of gradually increasing strengths. On the other hand, the unfixed embryo, if permitted to remain for some time in water, or even in normal saline solution, soon became soaked and swollen and lost much of its natural contour, and this no matter what the solution used —acid, alkali, distilled water, boiled water, water with a trace of alum, of lime, of formalin, or of spirit. In addition there were difficulties caused by movement of the fluid in which the embryo was suspended, or in the embryo itself, which often floated suspended in the water and gradually drifted to one side. These drawbacks made long exposures inadmissible, and therefore necessitated the use of low powers, such as 75 m/m planar lenses.

The author used such a lens, with a diameter of 18 m/m, made by Zeiss, and found that working with good daylight, close to a well-lighted window, good results were obtained with exposures of 5 to 10 seconds at F. 4, and an average of 30 seconds at F. 8 or F. 11. By stopping down to F. 22 and allowing 4 minutes' exposure when the subject permitted it, many finer details could be obtained, and in favourable conditions an exposure of only 80 seconds with this latter aperture sufficed. The embryos were placed in a glass capsule, containing cold distilled or boiled water, supported on a round stand made by Leitz, and adjustable by rack and pinion. The rack and pinion could be used for focussing, but sometimes shook the water and so caused the embryo to float out of the field. A vertical camera was used and the focussing done by adjusting the front carrying the lens. A perfectly black back-ground gave the most pleasing results, and was also of assistance in focussing, its strong contrast causing the whitish embryo to stand out in bold relief. For this purpose a piece of thick, black velvet, with fine, closely-set pile, was cut into a circular shape, and attached by melted paraffin to a thin disc of lead, the whole forming a useful screen which could be made in a few minutes and lasted well. Before placing the velvet in the capsule the fleece should be well brushed backward and forward under a tap of running water to drive out the air-bubbles. The author states that the embryos which he photographed were *in utero* in the living parent five minutes before, and he had only to drop them into the fluid with which the glass capsule was filled, to place the capsule on the stand beneath the lens, bring the embryo into the field with a touch of a soft camel-hair brush, focus it, cap the lens, draw the dark-slide, wait a few seconds until all objects seen reflected in the water appeared perfectly motionless, remove the cap gently, and expose the plate. The camera can be placed on a table or bench in front of any window with a good light.

Royal Microscopical Society.

April 21, Mr. E. J. Spitta, M.R.C.S., etc., Vice-President in the Chair. A large binocular microscope with accessories, made by Ross, in 1888, including three apochromatic objectives, presented to the Society by Lord Edmund Spencer Churchill, was described by Mr. Rousselet. Mr. Edward Heron-Allen, F.L.S., F.R.M.S., read a very interesting paper "On the Recent and Fossil Foraminifera of the Shore Sands of Selsey Bill, Sussex," which was illustrated by about 50 beautiful lantern slides of photo-micrographs taken with reflected light at magnifications of from 20 to 160 diameters. Mr. E. J. Sheppard, F.R.M.S., read a paper "On the Disappearances of the Nucleolus in Mitosis," the subject being illustrated by photographs and drawings on the board, as well as by four examples, three vegetable, and one Epidermis of Tadpole, exhibited under microscopes in the room. Mr. Heron-Allen said he had found in his slide box a slide which had been made to illustrate a paper recently read by himself and Mr. Arthur Earland, before the Quekett Microscopical Club, and which he was glad to be able to show upon the screen, as it represented the most remarkable powers of selection of material hitherto encountered in the study of the arenaceous Foraminifera. It represented a new species called *Technitella Thomsoni* (Earland), dredged by Mr. Earland in the Moray Firth. In this case the creature had formed its test entirely of the spicules of a particular kind of Echinoderm, and though there were no doubt plenty of these at the bottom of the sea in proportion to the grains of sand and other material to be found in the same area, the number of these plates was infinitesimal; yet this Rhizopod went about, and, in the most remarkable way, selected only these for its purpose.

Quekett Microscopical Club.

May 7. The Presidential Address, postponed from February 5, was delivered by Professor E. A. Minchin, M.A., F.Z.S., who dealt with "Some Applications of Microscopy to Modern Science and Practical Knowledge." An account was given of some of the remarkable advances that have been made in recent years in the knowledge of diseases caused by Protozoan parasites, examples selected were malaria, sleeping sickness, and yellow fever. The account of malaria was illustrated by a diagram of the various stages of the life-history of the parasite. Dealing with sleeping sickness, reference was made to Professor Kleine's recent discovery, that tsetse flies fed on an infected animal do not become infectious for about three weeks, and then apparently remain capable of infecting every animal that they feed on. Study of the life-history of the parasite was now necessary to find out what it was doing during this long incubation period. With regard to yellow fever, although much had been done the parasite had not yet been observed. It is practi-

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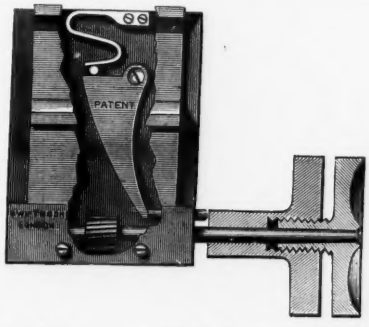
cally certain for many reasons that there is a minute parasite at work, and there are grounds for suspecting that it is a spirochæte.

Fine Adjustment to Sub-stage.

Messrs. James Swift and Son have recently constructed a new sub-stage fitted with their "Climax" fine adjustment, which actuates a lever in which the two arms are set at right angles to each other. The illustration shows the appearance of the adjustment clearly, and it will be noted that both the coarse and fine adjustments work upon one shaft, an arrangement the convenience of which is manifest. The sub-stage is fitted with the usual centring screws, and can be fitted to any of Messrs. Swift's bacteriological microscopes. English workers on subjects requiring maximum resolution have long been familiar with the advantages of what is known as "critical illumination," where the image of the illuminant (such illuminant being in almost all cases the soft and easily focussed light given by the edge of the flame of a paraffin lamp) is accurately centred to the optic axis of the objective, and focussed upon the object as carefully as is the objective itself. Objection is often raised by the unskilful worker that the whole field is not illuminated, but that a bright streak is seen across the



centre of the field, even with high powers, but in critical work only a small portion of the field is under examination, and the gain in definition within the borders of that streak needs only to be seen and carefully looked at to be appreciated. A very small variation in the focussing of the condenser, whatever may be said to the contrary, makes a marked difference in the definition (I am speaking, of course, of critical work with high powers) and it is here that the use of a fine adjustment to the sub-stage, such as is fitted by the best English makers alone, becomes more than a convenience, the ordinary rack and pinion being too quick, and too apt to shake the instrument.

Notes on some Insect Hairs.

By LT.-COL. F. WINN SAMPSON, F.R.M.S., F.E.S.

SOME months ago in West Africa, I was examining a specimen of *Sphegides*, when I observed that the hairs on the wings were different to any I had noticed before, and their appearance is shown in fig. 1.

The thickest and best specimens are generally to be found near the nervures, some of the finer hairs requiring very careful focussing and special arrangement of the illumination to enable the spiral appearance to be seen at all.

Up to the present time I have only found the same hairs on *V. Crabro* and *V. vulgaris*, but the spiral is not quite so boldly marked in these as in the African *Sphegides* before mentioned.

My apology for drawing attention to so minute a difference is that in these days even more microscopic variations are being used for purposes of classification.

It was whilst searching for more specimens of these spiral hairs that I noticed the curious arrangement of hairs on the front wing of *Bombus terrestris* shown in fig. 2. All the wing is covered with branched hairs similar to fig. 3, except the areas *a*, *b*, *c* which are sparsely covered with short stumpy hairs such as those shown in fig. 4.

The hind wing has these short hairs all over, except towards the base, where there are a few long branched hairs similar to those found on the body, but not like those on the front wing, the former being much longer and more branched.

About two years ago I showed Col. Bingham at the British Museum a small ant I caught in Calabar, S. Nigeria, and he requested me to get some more of them for him.

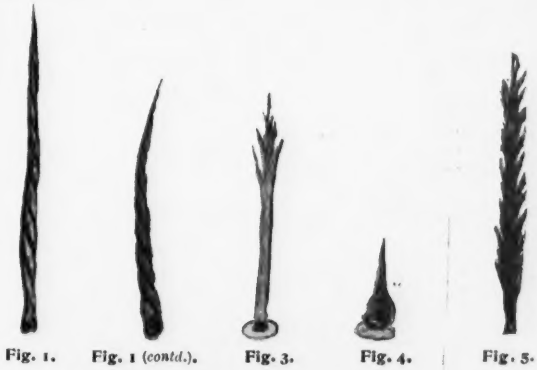


Fig. 1. Fig. 1 (*contd.*). Fig. 3. Fig. 4. Fig. 5.

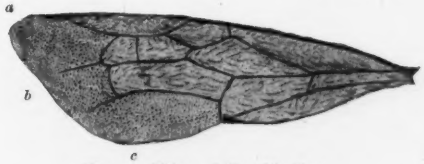


Fig. 2.—Wing of Humble Bee.

This I was unable to do until May last, when I found a nest of ants under the floor of my bungalow at Warri, S. Nigeria, and I brought a quantity of them to England, only to hear, alas, of Col. Bingham's death.

The peculiarity of these ants is that they have branched hairs on the body, legs, and head, which fact Col. Bingham had informed me was new to him.

I have since found similar hairs on other ants from different parts of the world, which I am now taking steps to get classified, but the large majority, at least of West African ants, have only plain hairs.

Fig. 5 represents these hairs.

[Note by Microscopical Editor.—Lt.-Col. Winn Sampson has kindly sent some of these ants to me for distribution, and I shall be glad to send one (as far as the supply goes) to any reader who cares to apply for same. Applications must be accompanied by the smallest possible bottle containing a little alcohol or methylated spirit, protected in a *strong* little box, a stamped and addressed *label*, and by the coupon to be found in the present issue of "KNOWLEDGE." Applications not conforming to these regulations will receive no attention.]

[*Communications and inquries on Microscopical matters should be addressed to F. Shillington Scales, "Jersey," St. Barnabas Road, Cambridge, Correspondents are requested not to send specimens to be named.*]

The Face of the Sky for June.

By W. SHACKLETON, F.R.A.S.

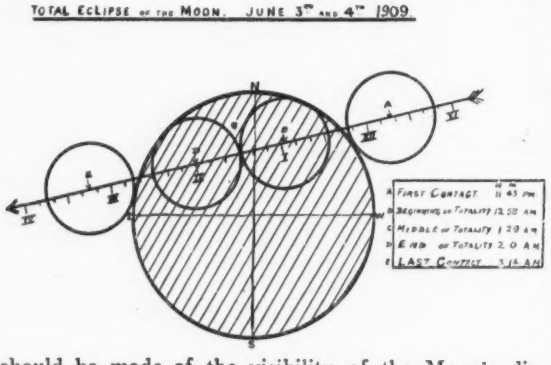
THE SUN.—On the 1st the Sun rises at 3.52 and sets at 8.4; on the 30th he rises at 3.48 and sets at 8.18. Summer commences on the 22nd, when the Sun enters the sign of Cancer at 2 a.m.; this is the longest day the Sun being $16^h\ 34^m$ above the horizon. The equation of time is negligible on the 14th and 15th, hence these are convenient days for adjusting sundials, as only the correction for longitude is needed. Sun-spots and prominences continue to be fairly numerous; at the time of writing there is an unusually large spot near the centre of the disc which appears to be very active when examined spectroscopically. There will be a total eclipse of the Sun on the 17th, invisible in this country and practically visible only from inaccessible regions; the path of totality crossing Siberia, the North Pole, and Greenland. The positions of the Sun's axis, equator, and heliographic longitude of the centre of the disc are shown in the following table:—

Date.	Axis inclined from N. point.	Centre of Disc S. or N. of Sun's Equator.	Heliographic Longitude of Centre of Disc.
May 31 ..	15° 55′ W	0° 39′ S.	31° 5′
June 10 ..	11° 59′ W	0° 34′ N.	258° 44′
,, 20 ..	7° 41′ W	1° 45′ N.	126° 22′
,, 30 ..	3° 11′ W	2° 53′ N.	354° 0′

THE MOON:—

Date.	Phases.	H. M.
June 4..	○ Full Moon	1 25 a.m.
,, 11..	☾ Last Quarter	2 43 a.m.
,, 17..	● New Moon	11 28 p.m.
,, 25..	☽ First Quarter	6 43 p.m.
,, 12..	Perigee.	4 18 p.m.
,, 25..	Apogee.	0 12 p.m.

There will be a total eclipse of the Moon on the evening of the 3rd and morning of the 4th. Totality lasts from 12.58 a.m. to 2.0 a.m. The magnitude of the eclipse is 1·164 (Moon's diameter = 1). Below is a diagram illustrating the passage of the Moon through the Earth's shadow. During totality observations


TOTAL ECLIPSE OF THE MOON. JUNE 3RD AND 4TH 1909
N
S
A FIRST CONTACT 11 43 PM
B BEGINNING OF TOTALITY 12.58 AM
C MIDDLE OF TOTALITY 1 29 AM
D END OF TOTALITY 2.0 AM
E LAST CONTACT 3.14 AM

should be made of the visibility of the Moon's disc, giving attention also to any variation in colour which may take place.

OCCULTATIONS.—The star ν Virginis, magnitude 4·2, is the only naked-eye star occulted before midnight during the month. The occultation takes place on the 24th at 9.15 p.m.

THE PLANETS.—Mercury (June 1, R.A. $5^h\ 50^m$; Dec. N. 23° 35′. June 30, R.A. $5^h\ 16^m$; Dec. N. 18° 52′) is in inferior conjunction with the Sun on the 14th. The planet is visible in the evenings for a few days at the beginning of the month, and in the mornings for a few days at the end of the month. On the 1st he sets at 9.29 p.m., and on the 30th he rises at 2.59 a.m.; on both dates the planet is situated in Taurus.

Venus (June 1, R.A. $5^h\ 13^m$; Dec. N. 23° 25′. June 30, R.A. $7^h\ 48^m$; Dec. N. 22° 29′) sets on the 1st at 8.52 p.m., and on the 30th at 9.26 p.m. The planet is situated on the confines of Taurus and Gemini, but is practically invisible throughout the month.

Mars (June 1, R.A. $22^h\ 28^m$; Dec. S. 12° 25′. June 30, R.A. $23^h\ 31^m$; Dec. S. 7° 4′) is increasing in brightness and is becoming a fairly conspicuous object in the morning sky. The planet is situated in Aquarius, and rises at midnight on the 20th.

Jupiter (June 1, R.A. $10^h\ 33^m$; Dec. N. 10° 28′. June 30, R.A. $10^h\ 46^m$; Dec. N. 9° 6′) is getting more to the West, but still remains a conspicuous object in the evening sky looking West after sunset. The planet sets at 12.57 a.m. on the 1st and at 11.4 p.m. on the 30th. The apparent diameter is diminishing, the equatorial diameter now being 35″, whilst the polar diameter is 2″·2 smaller.

The following table gives the satellite phenomena:—

Date.	Satellite.	Phenomenon.	P.M.'s. H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.	Date.	Satellite.	Phenomenon.	P.M.'s. H. M.
June				June				June			
1	I.	Ec. R.	9 32	10	III.	Ec. D.	10 40	21	II.	Oc. D.	9 47
3	III.	Ec. R.	9 47	15	I.	Oc. D.	9 53	23	I.	Sh. I.	10 19
5	II.	Tr. I.	9 33	16	I.	Tr. E.	9 30	24	I.	Ec. R.	9 46
7	II.	Ec. R.	9 46		I.	Sh. E.	10 42	30	IV.	Ec. R.	9 50
	I.	Tr. I.	10 45	17	III.	Oc. D.	9 35		II.	Tr. E.	9 53
8	I.	Ec. R.	11 27								

"Oc. D." denotes the disappearance of the Satellite behind the disc, and "Oc. R." its reappearance; "Tr. I." the ingress of a transit across the disc, and "Tr. E." its egress; "Sh. I." the ingress of a transit of the shadow across the disc, and "Sh. E." its egress; "Ec. D." denotes disappearance of Satellite by Eclipse, and "Ec. R." its reappearance.

Saturn (June 1, R.A. $1^h\ 17^m$; Dec. N. 5° 38′. June 30, R.A. $1^h\ 26^m$; Dec. N. 6° 23′) is a morning star in Pisces, rising at 1.16 a.m. on the 15th.

Uranus (June 15, R.A. $19^h\ 27^m$; Dec. S. 22° 24′) is situated in Sagittarius The planet rises about 9.50 p.m. near the middle of the month, and is on the meridian about 2 a.m. He can just be discerned with the naked eye about 2° South-East of the star π Sagittarii.

Neptune (June 15, R.A. $7^h\ 9^m$; Dec. N. 21° 48′) is almost out of range, as early next month he is in conjunction with the Sun. The planet is only visible for a short time after sunset, as he sets about 9.30 p.m. on the 15th.

TELESCOPIC OBJECTS:—

DOUBLE STARS, &c.—β Scorpii, XVI.^{h} 0^m, S. 19° 33′, mags. 2·7, 5·2; separation 13″·1.

ϵ Lyræ, XVIII.^{h} 41^m, N. 39° 33′, known as the "double-double" star, can just be separated by the naked eye, but with a pair of opera glasses it is readily divided into two components, ϵ_1 and ϵ_2, mags. 4·4 and 4·8. Using a 3-in. telescope and a power of about 120, each of these stars can again be divided into pairs, 3″·2 and 2″·6 apart respectively, each component being about magnitude 5·5.

M 57 (Lyra), the "ring" nebula. This nebula is the only annular nebula accessible to telescopes of about 3 in. aperture, and even then requires good seeing. It is easily found, being situated about $\frac{1}{3}$ of the distance from β to γ Lyræ.

M 80 (Scorpio). A compact globular cluster half way between α and β Scorpii; looks like a nebula in small telescopes.